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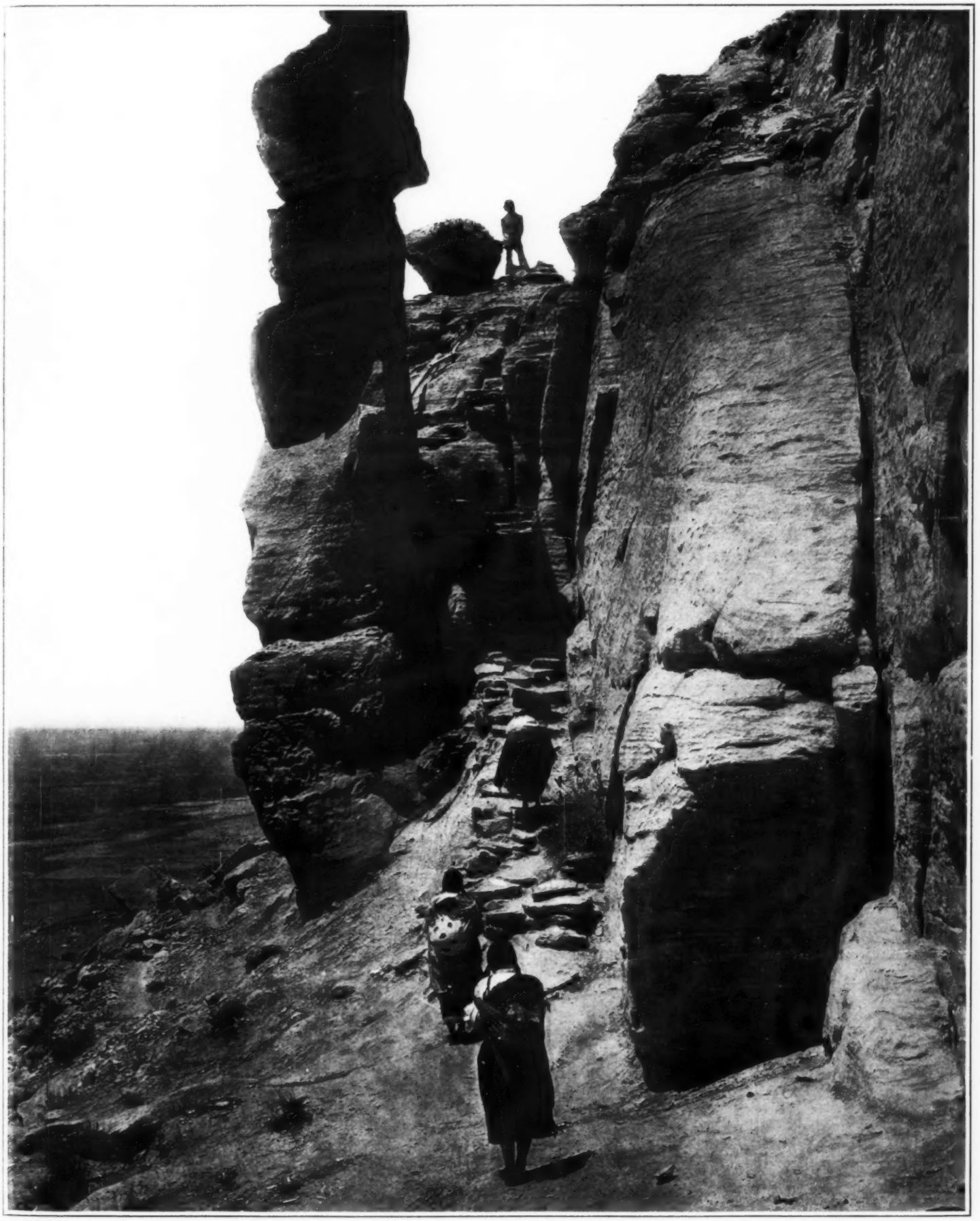

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The gateway of Acoma, a pueblo city in New Mexico, on the summit of a mesa over 600 feet above the plain

SCENES IN ACOMA [See page 152]

The Classification of the Chemical Elements

The Fundament of Chemistry

By Ingo W. D. Hackh

"Everything in its beginning proceeds from the incomplete to the complete."[1] This procedure we call progress, for progress is measured by the increase in value, spiritual or material.

The history of Science in general and of Chemistry in special is a vivid illustration of the progress of human knowledge, of its growths. However it does not grow with equal speed throughout the centuries, but once begun accelerates its growth and progresses in geometrical proportion. As the parabola approaches both a perfect ring and a straight line, so the entireness of human wisdom drifts toward perfection, yet never reaches its goal.

The labors of the scientist today, thanks to the improved ways of recording and transmitting thoughts and discoveries, are for the benefit of all and as in every quarter of the globe, in peace and war, research is going on the sum total of the sage's effort piles ever on and calls for specialists in every field. It was not very long ago when a man was still able to master all of what was known in the science of chemistry; to-day it takes the sweat of one's brow to keep abreast in a side-branch of it. But in every science there are certain fundamentals and the better one understands the basis of the science the clearer and more definite becomes the conception of ideas. Chemistry of today enters in every phase of life and sad to say it is a drudgery to many a student and mature person who needs the science, but lacks the foundation.

WHAT'S WHAT?

Now to dwell a little upon the "What's what in chemistry." This is not only a very interesting theme but also reveals a wonderful and systematic view of the structure of the universe and illustrates the orderly sequence of the great mystery of nature. Perhaps no other natural law, besides some fundamental astronomical doctrines, has been so complete and fully revealed by the human race, as the system of matter, commonly known as the periodic system of the elements. It took centuries to grasp the idea of chemical elements as being the bricks of the universe and that out of these building stones all matter is composed.

Number of Elements.—From many facts it is apparent today that there are 92 of these bricks or elements, and of these five have not yet been discovered or found. Naturally not all of them are of equal importance, about 14 are of great general interest, as forming the greater part of the mass of the solid portion of the earth, of the water and atmosphere and of all animal and vegetable matter, the corner-stones of the universe. (See in Fig. 1 the elements of the first two periods, marked with a longer bar in the last column). About thirty elements claim interest on account of special uses made of them; these occur not so frequently and not in such large quantities as the first group and are not essential for the formation of organic matter, yet they are used for various purposes in everyday life. (Marked in Fig. 1 by a shorter bar). The rest of about 45 elements are found in small quantities in nature and they are more or less of scientific interest, the decorative stones of the universe which complete the structure.

Groups of Elements.—It was natural that with an increase of knowledge and the discovery of new elements a classification was attempted. With the discovery of exygen the foundation of chemistry was laid and the first definite modern idea of an element based upon experiment and not upon speculation was formed. Although not many elements were known it was possible to group some of them according to their properties in groups of three, the "triads" of Doebereiner (1829), e. g. Ca-Sr-Ba, P-As-Sb, Cl-Br-I, Cu-Ag-Au. Incidentally it was found that the atomic weights of these elements had a certain relationship to each other, that is the atomic weight of the member in the middle was approximately the mean of the two outer members. This idea was further developed as more new elements where discovered by Cooke (1854), DeChancourtois (1865) and Newlands (1865), the latter applying the idea in a different sense in his "law of octaves" by showing, that as in musical notes, the seventh element has relationship to the first one if they are arranged with increasing atomic weight. His idea was at first ridiculed, but became prominent when in 1869 Mendeleeff and independently Lothar Meyer presented the socalled "natural system" or periodic system of the elements. The periodic table thus established remained until the end of the last century unchanged, it was incomplete and fragmentary, many empty spaces were there, and while in some respects it served wonderfully well, it was unsatisfactory in others, for it was only the partial recognition of a natural law.

Interelements.—Two great discoveries of the last two decades completed our knowledge and at the same time opened up new avenues of research with a new aspect of the universe. The first discovery was the isolation of "rare gases" by Ramsay which began in 1894 with Argon. These elements: He, A, Ne, Kr, and Xe are absolutely inert gases, that is they do not enter into any combination with any other element, form therefore no compound, and are in small quantities present in the atmosphere. This inertness was something entirely new; up to that time all elements could be brought into combination, although some were more "aristocratic" or "noble" than others, like gold or platinum for example. What to do now with elementary gases which have no chemical property? Elements without chemistry they were and so they were assigned to a "zero group" either at the beginning or end of the periods in the periodic system. And lo! once there they fitted in so snugly and furnished a long felt but not recognised "missing link" for they combined the two extreme ends of a period, they formed the bridge from a non-metallic halogen (electro-negative element) to a metallic alkali (electro-positive element). For this reason we may speak of these elements, the rare or inert gases, as the terminals of the periods, which are either positive nor negative, and whose electro motive force we consider to be $\pm \infty$ and whose electrons form a stable system and can therefore have no valency.

When now the elements are arranged according to increasing atomic weight, as done in Fig. 1, the line is a continuous one with periodic changes and does not contain the awkward break between the negative halogen and positive alkali-metal.

Radioactive Elements.—The continuity of the periodic line thus established, the next question is the limits of this line. This found its answer by the second great discovery, namely the discovery of the radio active substances in 1899. This revealed gradually the fact, that the elements with the highest atomic weight, thorium and uranium, spontaneously and slowly break apart into elements of lower atomic weight. That is to say the atom of such an element has become so complex that they are under the present cosmic conditions of our earth unstable and disintegrate. These elements therefore form the upper limit of the line. Uranium is thus the last member of the line of terrestrial elements. But what about the lower limit? Hydrogen is the lightest known element and possesses the lowest atomic weight and is therefore assumed to be the first member of the line. Although there are some indications that elements lighter than hydrogen exist in some celestial objects, like "coronium" in the sun corona and "nebulium" in the nebulosities, as these "celestial" elements have however never been found so far upon our earth they need not to be considered in the periodic system of the "terrestrial" elements. And even if they should be found, they would complete the "zero" period, whose only member at present is hydrogen.

THE PERIODIC SYSTEM.

The arrangement of the elements given in Fig. 1 is the basis of the periodic system. Taking the "inert gases" as the terminals or the starting and endpoints, there are five well defined periods from one inert element to the other. These are designated in the first column as I, II, III, IV and V and they are found to be of unequal length, namely the first two containing 8, followed by two with 18 and finally one with 32 elements. The first three elements following an inert gas are always strong positive, while the last three before an inert gas are always strong negative and thus a kind of a transition is formed by the fourth element, or the elements of the carbon group. This is best illustrated by the following schema:

group	0	A	2	3	4	5	6	7	8 or 0
E.M.F.	+∞	+++	+ +	+	+0	-	- -	---	+∞
I per	2	3	4	5	6	7	8	9	(10)
II ·	10	11	12	13	14	15	16	17	(18)
III ·	18	19	20	21	22				
					32	33	34	35	(36)
IV ·	36	37	38	39	40				
					50	51	52	53	(54)
V ·	54	55	56	57	58				
					72				
					82	83	84	85	(86)

In this schema the numbers correspond to the "atomic number," which is also found in the second column of Fig. 1.

Atomic Number.—This number is not only of the successive character as indicated in Fig. 1, but is also derived from the relative position of the first line in the X-ray spectra of an element. All elements emit under certain physical conditions vibrations or frequencies, which extend over a wide range of wave lengths. A certain section of these wave lengths is visible to the eye as "color" and "light." Thus *e. g.*, in the visible sunspectrum the Fraunhofer lines are caused by certain elements. But the series of wave lengths extend much farther and near the beginning in the invisible region, with very short wave lengths, vibrations which can neither be seen nor photographed, but detected only by the electroscope, a "spectrum" of definite lines for certain elements can be obtained. By arranging now the elements according to the first line of these X-ray spectra, these first lines show a mathematical relationship to each other and form a mathematical series. In this series beginning with H and ending with U are five gaps, the first one being between the spectra of molybdenum and ruthenium and it is assumed that an element whose spectrum should fall between these two known elements, has not yet been discovered. Numbering now the members of the series, by beginning with H as 1 the so-called atomic numbers are obtained, which correspond exactly to the successive numbers of the elements, when arranged with increasing atomic weight, as in Fig. 1.

Periods and Groups.—As already indicated the elements from one noble gas to the other form a period, in each period the character of the elements changing from strong positive to strong negative, the transition being formed by an element of the carbon group. The longer periods are characterised by two or three elements of the carbon groups, and there are then respectively one or two subperiods. Writing now the periods horizontally and under each other, as in the above schema, certain relationship exists in the vertical direction, and these elements form closely related groups, as *e. g.*, in the schema the elements of group 1 would consist of those with atomic numbers 3, 11, 19, 37 and 55. (Li-Na-K-Rb-Cc). ***Only the first and last four members of each period show characteristic group-relationship,*** the members of the subperiods exhibit only traces of this group-relationship (for simplicity sake they are therefore eliminated from the above schema). The properties of the elements of the subperiods are more closely related in the same subperiod and can therefore be spoken of as "period-relationship." These two types of relationship are best illustrated in Fig. 2, in which the elements are arranged in a spiral.

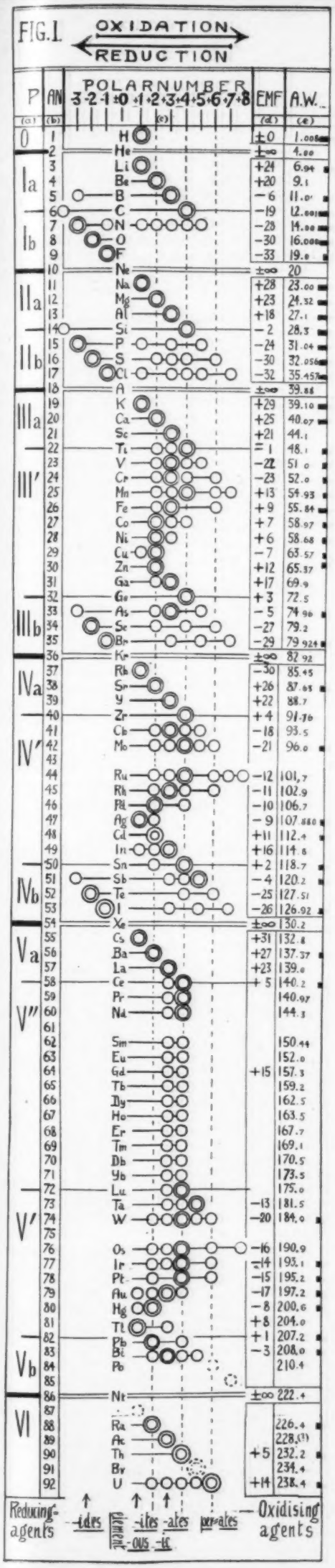
The Helix Chemica.—The spiral or helix[2] is instructive in many respects, for it illustrates the position of each element in the system very well. The terminals and transition elements are distinctly characterised and the classification is shown into the three great classes of Nonmetals, Lightmetals and Heavymetals. For the study of the underlying principle the spiral is ideal, but for practical purposes its technical construction is cumbersome and a tabular representation is given in Fig. 3. This table, while not so perfect as the spiral, has many advantages superior to the old classical table of Mendeléeff and Meyer, usually given in text-books. Whatever will be said of the table, should be studied on the spiral also.[3]

Physical Properties.—Both the figure and the table are something like a map or chart of matter on which

[1] Eudemus.

[2] See also Emerson, Am. Chem. Journ., 45, p. 160, 1911.

[3] See also Hackh, A modification of the Periodic Table, Am. Journ. of Science, 46, p. 481, 1918.



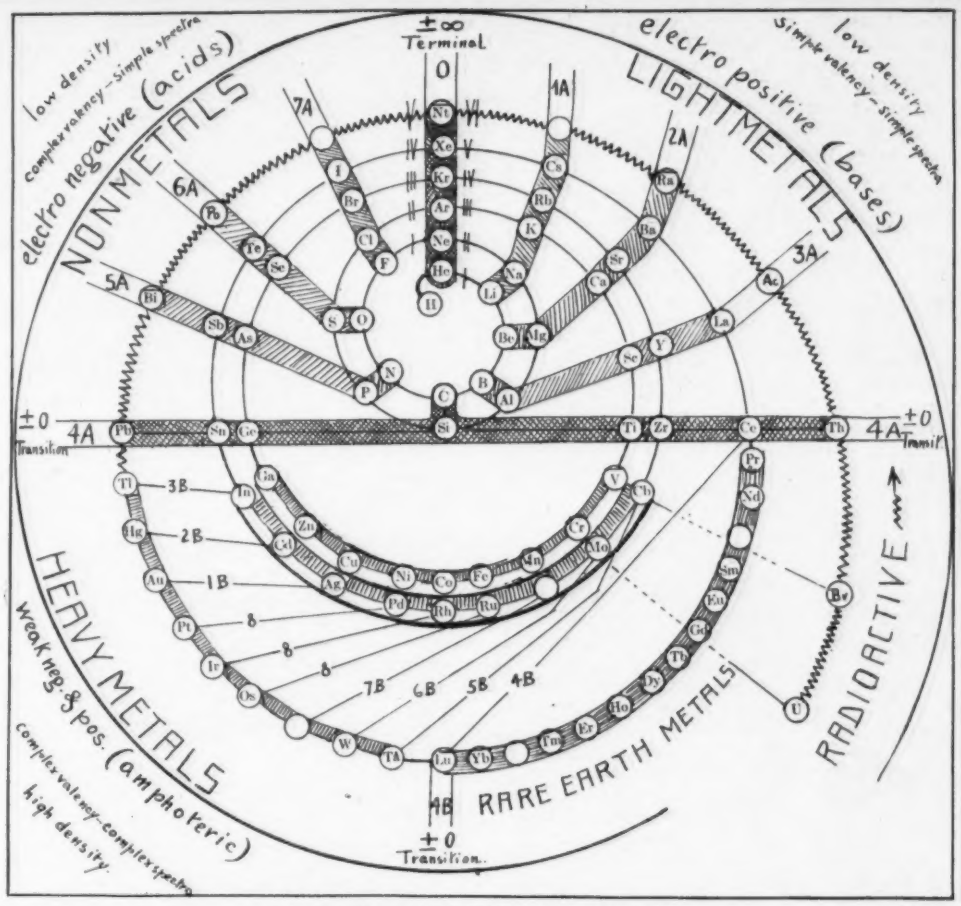


Fig. 2. The periodic spiral of the elements

In this figure the periodic chain (fig. 1) is bent in such a way that elements of similar properties come together.

NOBLE GASES are the terminals, the elements of the CARBON GROUP the transition points. The elements between the terminals form a PERIOD, those between the transition points a SUBPERIOD.

The first two periods have only two subperiods each, e. g., Ia and Ib.

The next two periods have three subperiods each, e. g., IIIa, III′ and IIIb.

The very long period has four subperiods namely Va, V″, V′ and Vb.

LIGHTMETALS are the elements of the a-subperiod, NONMETALS are the elements of the b-subperiod, HEAVY METALS are the elements of the ′ —subperiod, RARE EARTH METALS are the elements of the ″ —subperiod.

In the upper half of the spiral the properties of the elements are along the axis (group-relationship), while in the lower part the similarities are along the radius (period-relationship).

(See also EMERSON, Am. Chem. Journal, vol. 45, p. 160, 1911, and Science, vol. 34, p. 640, 1911.)

can be located boundary lines and zones of permeation between the maxima and minima of properties. Thus we have for the electro motive force the following diagram (to be superimposed upon the table):

±0	strong –	± ∞	strong +	±0
±0	weak –		weak +	±0

Fig. 1. The periodic chain of elements

The elements are arranged according to increasing atomic number or atomic weight. The whole series from 1 to 92 is divided into six sections or PERIODS, which are again subdivided into subperiods (see figure 2).

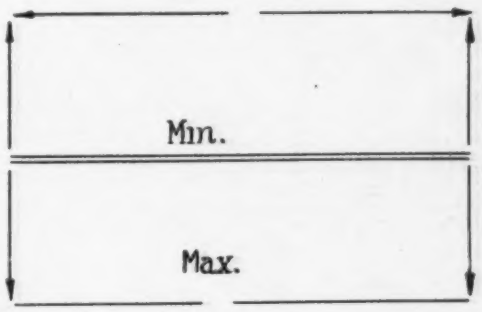
POLARNUMBER is the arithmetical expression of the valency. Some elements possess only one polarnumber and form therefore only one TYPE OF COMPOUNDS. Other elements may have two or more polarnumbers corresponding to two or more types of compounds. The circles in the figure give the value for the polarnumber or polarnumbers for each element.

NOMENCLATURE or the names for the different types of compounds of an element are indicated at the bottom of the figure by the suffixes. For metals or cations—OUS indicates the lower, and —IC the higher polarnumber. For nonmetals or anions the order is —IDE, —ITE, —ATE and PER— —ATE, beginning wibt the lowest, and ending with the highest polarnumber. Thus there are e. g. (polarnumbers in parenthesis) mercurous (1) and mercuric (2); cuprous (1) and cupric (2); ferrous (2), ferric (3) and ferrate (6); manganous (2), manganic (3), manganite (4), manganate (6) and permanganate (7); sulfide (—2), sulfite (4) and sulfate (6); chloride (1), chlorite (1), chlorate (3) and perchlorate (5).

OXIDATION OR REDUCTION is involved whenever one type of compound changes to another type of compound. The polarnumber can either be augmented (increased) or diminished (decreased). The first process is OXIDATION. The augmentation is called OXIDATION, e. g. a change from ferrous to ferric, from ferric to ferrate, or from sulfide to free sulfur, from free sulfur to sulfite, from sulfite to sulfate. The diminution of the polarnumber is REDUCTION, e. g. from ferrate to ferric, from ferric to ferrous, from ferrous to free iron, or from sulfate to sulfite and free sulfur, etc.

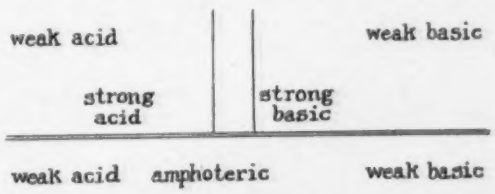
OXIDISING and REDUCING AGENTS are substances which bring about oxidation and reduction. In this process the oxidising agents are reduced, and the reducing agents are oxidised. In a general way: the greater the difference between the polarnumbers, the more active the substance. E. g., permanganates, perchlorates, etc., are strong oxidising agents, while sulfides, iodides, ferrous salts, etc., are reducing agents.

If the values for density of the elements are inserted a striking regularity is shown which can be expressed by arrows pointing toward increasing density. These arrows are located as follows:



indicating the minimum at hydrogen, the maximum at osmium. For all physical constants of the elements these tables or charts are very instructive, so *e. g.*, for melting-point, boil.ng-point, compressibility, atomic refractivity and so on.

Chemical Properties. The chemical characteristics of the elements can equally well be studied, for there are the acid- and base-forming elements on the chart, whose zones gradually infiltrate from strong basic to weak basic to atmospheric to weak acid to strong acid or vice versa:



The strength of an acid or base being measured by the degree of ionisation, that is the formation of H^+ (hydrogen ion) in the case of acids, and OH^- (hydroxid ion) in the case of bases, this phenomena is inversely proportional to the electro motive force.

The formation of compounds is illustrated by the simple diagram:

mostly colorless and soluble salts

many colored and insoluble salts, many double salts.

The occurrence of the elements in nature is interesting for this is in a certain way the expression of the chemical affinity among the elements. There is no doubt, that the "affinity" or force that unites the atoms of different elements is not purely electric in character. Many phenomena cannot be explained by electro motive force alone but point to a selective tendency among the elements. This elective force is hinted at in the following diagram showing the natural occurrence of the elements. A comparison of this diagram with the diagram of the e.m.f. is interesting and instructive.

occur native sulfides are common easily reducible	occur never native oxides are common difficult to reduce
occur never native oxides are common difficult to reduce	occur native sulfides are common easily reducible

Thus the nonmetals and the weak electro-positive metals occur native and in the form of their single or double sulfides, they are very easily reduced (and difficult to oxidise).¶ The reverse holds true for the lightmetals and the weak electro-negative metals.

Classification of Elements. In a very general way some properties of the elements have been outlined and some boundary lines more or less sharply indicated. In all the diagrams one general characteristic is noticed: In the upper part the noble gases form the transition between abrupt changes in the properties, while in the lower part of the table there is a gradual transition. An intelligent study of chemistry uses therefore this natural system and draws the following lines of demarcation as a classification of the elements:

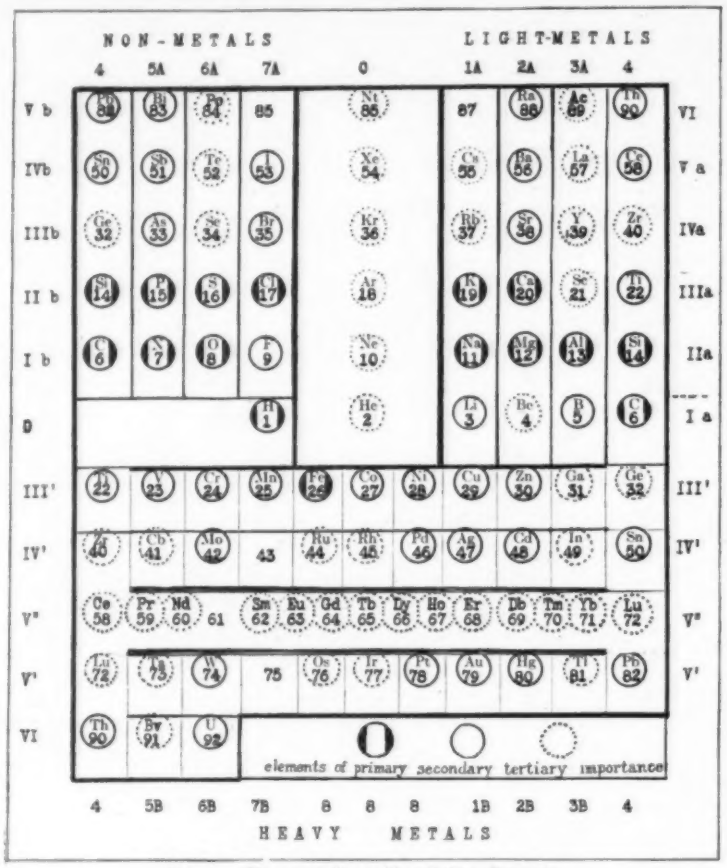


Fig. 3. The periodic table of the elements

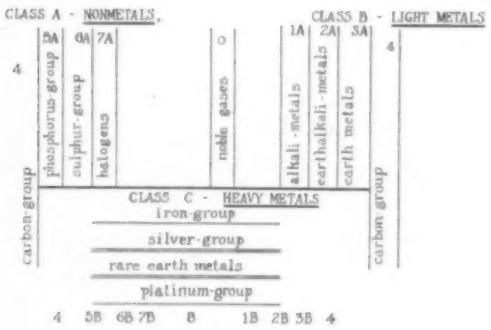
This figure is a tabular arrangement of the spral (fig. 2) and represents a "chart of matter" with the longitudes or groups and latitudes or periods. The position of an element in this table indicates its properties. (See text and also HACKH, Am. Journ. of Science, vol. 46, p. 481, 1918; Journ. Am. Chem. Soc., vol. 40, p. 1043, 1918.)

In the upper half of the table GROUP-RELATIONSHIP (similarity in vertical direction) prevails, while in the lower half of the table PERIOD RELATIONSHIP (similarity in horizontal direction) is predominant.

A heavy circle marks the elements of PRIMARY importance, these occur abundantly in the nature (lithosphere, hydrosphere and atmosphere) and are essential to life (biosphere). They are the fundament of every industry and of universal use.

A plain circle marks the elements of SECONDARY importance which occur less abundantly and are of special use in industries.

A dotted circle indicates the elements of TERTIARY importance, which are of rare occurrence and have no or little practical use, and are therefore of scientific interest only.



The classes and groups are:

Class A—Light Metals or basylous elements possess from one to three valence electrons, are therefore strongly electro-positive. Their oxides form with water the bases which unite with acids to form the salts.

GROUP 1A—*Alkali-Metals*: Li, Na, K, Rb, Cs. monovalent; sulfides, oxides, carbonates and many salts soluble in water; melting point low; density low; decompose water at ordinary temperatures, oxidise rapidly.

GROUP 2A—*Earthalkali-Metals*: Be, Mg, Ca, Sr, Ba. bivalent; sulfides and oxides soluble, carbonates insoluble; decompose water at ordinary temperature slowly, oxidise less rapidly.

GROUP 3A—*Earth-Metals*: B, Al, Sc, Y, La. trivalent; sulfides soluble, oxides and carbonates insoluble, decompose water at 100-200°, oxidise at higher temperature.

Class B—Heavy Metals or amphoteric elements possess from one to eight free valence electrons which may be interchangable. They may be either weak electro-negative or weak electro-positive, and form either weak bases or weak acids.

GROUP 3B — Ga, In, Tl.
GROUP 2B — Zn, Cd, Hg.
GROUP 1B — Cu, Ag, Au.
GROUP 8 — Fe, Co, Ni; Ru, Rh, Ru; Os, Ir, PT.
GROUP 7B — Mn.
GROUP 6B — Cr, Mo, W, U.
GROUP 5B — V, Cb, Ta.

Only the first and last groups are sharply characterised, the other groups toward the center merge into each other (period-relationship), thus e. g. the iron-group embraces Cr, Mn, Fe, Co, Ni, CU. The sulfides, oxides, carbonates and many salts are insoluble in water. The higher the atomic weight the less oxidised.

Class C—Nonmetals or acidulous elements possess from five to seven free valence electrons and are therefore strongly electro-negative. They form the acids.

GROUP 5A—*Phosphorus-group*: N, P, As, Sb, Bi. pentavalent and trivalent;

GROUP 6A—*Sulphur-group*: O, S, Se, Te. hexa- tetra- and bivalent.

GROUP 7A—*Halogens*: F, Cl, Br, I. hepta- penta-, tri- and mono-valent.

Class D—Transition Elements are the two groups of elements which form the bridge from one class to the other:

GROUP 4A—*Carbon-group*: C, Si, Ti, Ge, Zr, Sn, Ce, Lu, Pb, and Th. They are tetravalent, and as according to the newer theories the electrons of stable compounds form systems of "eight," these elements may combine with themselves just as readily, as with the atoms of another element. Thus e. g. a carbon-atom has to another carbon-atom the greatest affinity, forming the many thousands of carbon-compounds of organic life. Silicon is predominant in the mineral world and Titanium is in the spectra of all heavenly bodies.

The carbon-group forms the transition from the Light-metals to the Non-metals and Heavy-Metals, in other words the framework of the system.

GROUP 4B—*Rare Earth Metals*—Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb. Tetravalent and apparently tri-valent. From the preceding carbon group these elements differ in their more metallic properties. They are characteristic for their similar chemic properties. In compounds they occur as double-atoms, that is e. g. Pr_2Cl_6 and not $PrCl_3$ and their structure indicates therefore tetra-valency:

GROUP O—*Noble Gases or Inert Elements:* He, Ne, Ar, Kr, Xe, possess eight valence electrons which form a stable "system of eight." They enter into no chemic combintion, and form the transition from the halogens to the alkali-metals, that is the elements with the strongest electro-potential.

The elements, or bricks of the universe are thus classified and in making as many charts as possible, the student will become familiar with the relationships existing among the elements. These relationships are so marked and often related by mathematical laws, that many modern ideas of the constitution of the atoms have been built upon it. They are more or less interesting but cannot here be dealt with, where the practical aspects are mainly in view.

HOW'S HOW?

Having classified the "What's what" the next logical step is to consider how the elements react with each other. The number of compounds is very large, yet this number is not unlimited, but greatly limited by the properties of an element and it depends mainly upon the valency or polarnumber.

VALENCY AND POLARNUMBER.

The term valency is familiar to the reader, it is the relative combining-power of an atom in regard to hydrogen. Polarnumber is the arithmetical expression of this valency, the value of which can have either plus or minus signs and can also be zero. In the free state an element has the polarnumber of zero, because it entered into no union with another element. In compounds the polarnumbers are arrived at by assigning to oxygen the value -2 and to hydrogen the value $+1$. In each stable compound the sum of the polarnumbers must be zero. Thus we have e.g. for water H_2O

for hydrogen	$2 \times (+1) = +2$
for oxygen	-2
and therefore the total	$=0$

In order to find the polarnumber of any element in a compound one proceeds from the known ones and assigns the residual value to the unknown, e.g. the polarnumber of sulphur in H_2SO_4= sulfuric acid, is found as follows:

Hydrogen	$2 \times (+1) = +2$
Oxygen	$4 \times (-2) = -8$
	-6

$+6$ remains for sulfur therefore in order to make the total sum ± 0. In a similar way one finds the polarnumber for sulfur in sulfurous acid H_2SO_3 be $+4$, and for sulfur in hydrogensulfide H_2S to be -2. For sulfur there are therefore the polarnumbers -2 (in H_2S), ± 0 (in free S), $+4$ (in H_2SO_3), $+6$ (in H_2SO_4). The recognition of these different polarnumbers is of fundamental importance and one of the most common errors is the belief that an element can only exist with one valency or polarnumber. The different polarnumbers of the elements represent the different series of compounds. Thus some elements, like the alkali-metals, form only one series of compounds with polarnumber of $+1$. Other elements form two, three or more different types of compounds.

TYPES OF COMPOUNDS.

These different types of compounds of one and the same element have distinctly different properties and need not resemble each other, but can by certain chemical means be transformed from one into the other type. Thus there has been recognised for a long time the ferrous-compounds and the ferric-compounds, cuprous and cupric, chromous and chromic and so on.

NOMENCLATURE.

An indication of the nomenclature of these compounds is given in table 1, where at the bottom of the table the suffixes are recorded. The metallic elements with lower polarnumber are always the -ous-compounds, those with higher polarnumbers the -ic-compounds. The nonmetals, when negative, are the -ides, like e.g. sulfide, nitride, selenide, carbide, etc. In their oxy-compounds the nonmetals have a positive polarnumber and the lower one is the -ite, the higher one the -ate, and perhaps the per- -ate. Thus there are e.g.

Chlorine (−1) Chlorite (+3) Chlorate (+5) Perchlorate (+7)
Sulphide (−2) Sulfite (+2) Sulfate (+4)
Nitride (−3) Nitrite (+3) Nitrate (+5)
and among the amphoteric metals there are e.g.
Chromous (+2) Chromic (+3) Chromate (+6)
Manganous (+2) Manganic (+3) Manganate (+6) Permanganate (+7)

This nomenclature is indicated in table 1.

OXYDATION AND REDUCTION.

Whenever one type of compound is transformed into another type of compound, the chemical reaction is then called oxydation and reduction. *If the polarnumber is increased or augmented it is oxydation*, and if *the polarnumber is decreased or diminished it is reduction*. Thus the transformation of chloride to chlorine is oxidation. From chlorine to chlorite, from chlorite to chlorate is also oxidation. The reverse reaction, e.g. from perchlorate to chlorate or chlorite, from chlorate to chlorite or chlorine, from chlorine to chloride is reduction. In table 1 the arrows indicate the direction in which a transformation is either oxidation or reduction. Both terms have come down from the early modern chemistry, where it was believed that oxygen is essential to an oxydation, and hydrogen essential to a reduction. Today the terms have been enlarged to describe a certain class of reactions and it is unfortunate that the terms are thus misleading. Augmentation for oxidation, diminution for reduction would perhaps better indicate the nature of the reactions. The majority of the students at our universities are laboring under the misconception of the principle of "oxidation and reduction," which is based upon the different types or series of compounds and a close study of table 1, constantly used as a reference, will be of benefit in understanding certain chemical phenomena. If the classification and suggestions of this paper will prove to be an incentive to further study, or if it will give a different aspect of the subject matter, its mission will be fulfilled. However everything has to be "chewed well" before it can be digested, and if at the first reading a thing is not understood, it will become clearer by repeated study and then—interesting.

Fishing with Spider's Webs*

By E. W. Gudger, Professor of Biology, State Normal College, Greensboro, N. C.

LOUIS BECKE, author of many interesting books on the life and customs of the South Sea islanders and on the habits of the fauna found therein, in one of these books, 'Neath Austral Skies (London, 1909), tells the following interesting story: He says that many years ago he was discussing the customs, habits, and manner of life of the inhabitants of western Polynesia with Dr. J. S. Kubary, a German naturalist and traveler of high standing. They were at the time traversing a path through the mountains of Ponapé, one of the islands of the Caroline Archipelago, lying northwest of New Guinea.

It was early in the morning and spiders' webs with the dew on them were found everywhere. They were very large, so much so that occasionally one of them would obstruct the path of the travelers, and would have to be broken through with a stick. The size, strength and beauty of these webs were so extraordinary as to attract Becke's attention, and he spoke to Kubary of them. However, the German assured him that these were nothing compared to those which he had heard were to be found in the vicinity of Astrolabe Bay on the northeastern coast of that strange island-continent, Papua or New Guinea.

Kubary told his companion that he had read in either a letter or a publication by the distinguished Russian naturalist, Baron Nicolai Miklucho-Maclay, the statement that the mountain-dwelling tribes about Astrolabe Bay used similar spider-web nets for catching fish in their mountain streams.

Now Miklucho-Maclay was a scientist of high standing, especially in ichthyology, a traveler of wide acquaintance among the savage cannibals of New Guinea and the South Sea Islands, and had for some time resided among the tribes inhabiting the shores of Astrolabe Bay.

Whether or not the Baron had actually seen the natives use the large spider-webs for catching fish, Kubary could not say; but he certainly believed that the former had grounds for making the statement. Kubary's own notion was that the natives somehow or other were able to remove the nets whole and uninjured from the branches of the trees between which they had been spun, and having fastened them with proper supports across the narrow streams, drove the fish into them.

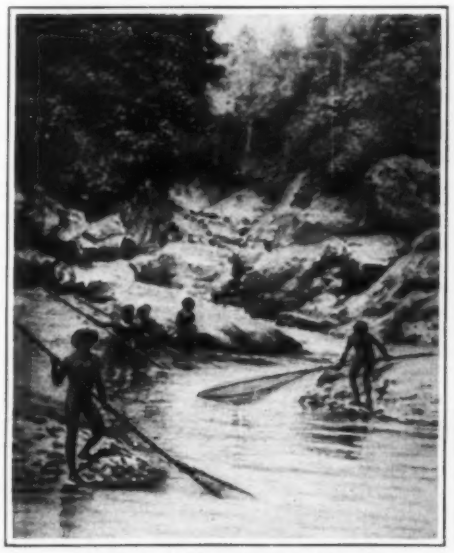
*From the Bulletin of the New York Zoological Society.

Becke next relates that years later, in a conversation with Sir John Robertson, Premier of New South Wales and father-in-law of Miklucho-Maclay, he spoke of the death of the latter from fever in New Guinea, and expressed great regret that the loss of the collections, journals, etc., of the naturalist probably made it impossible ever to trace down the spider-web fish-net story. Sir John, however, laughed at the story and expressed his belief that his son-in-law was simply playing on the credulity of the German. I have had careful search made of all the works available in the

New Guinea native and his spider-web net
Reproduced from Two Years Among New Guinea Cannibals

Library of Congress of both Kubary and Miklucho-Maclay, but with barren results so far as finding anything confirmatory of this interesting story.

However, from another source we now come to a most important confirmation of the spider-web fish-net story. During the past summer while at work in the American Museum of Natural History, New York City, on the Bibliography of Fishes, under the editorship of Dr. Bashford Dean and Dr. Charles R. Eastman, I examined a considerable number of books of travel to get



Natives of New Guinea fishing
Reproduced from Two Years Among New Guinea Cannibals

fish references. Among these was one entitled Two Years Among New Guinea Cannibals: a Naturalist's Sojourn Among the Aborigines of Unexplored New Guinea (London, 1906). The author is Mr. E. A. Pratt, a natural history collector of standing, and Gill Memorialist, 1891, of the Royal Geographical Society of Great Britain. Mr. Pratt spent two years in New Guinea, mainly among the aborigines in the vicinity of Yule Bay on the southeast coast where he collected insects and birds-of-paradise. This book gives an interesting account of his experiences during this time. On pages 266 and 267 is found the following remarkable account of fishing with the spider-web nets. The accompanying figures are reproductions of Mr. Pratt's plates:

"One of the greatest curiosities that I noted during my stay in New Guinea was the spiders' web fishing-net. In the forest at this point (Waley, near Yule Bay), huge spiders' webs, six feet in diameter, abounded. These were woven in a large mesh, varying from one inch square at the outside of the web to about one-eighth inch at the centre. The web was most substantial, and had great resisting power, a fact of which the natives were not slow to avail themselves, for they have pressed into the service of man this spider which is about the size of a small hazel-nut, with hairy, dark-brown legs, spreading to about two inches. This diligent creature they have beguiled into weaving their fishing-nets. At the place where the webs are thickest they set up long bamboos, bent over in a loop at the end. In a very short time the spider weaves a web on this most convenient frame, and the Papuan has his fishing-net ready to his hand.

"He goes down to the stream and uses it with great dexterity to catch fish of about one pound in weight, neither the water nor the fish sufficing to break the mesh. The usual practice is to stand on a rock in backwater where there is an eddy. There they watch for a fish, and then dexterously dip it up and throw it on to the bank. Several men would set up bamboos so as to have nets ready all together, and would then arrange little fishing parties. It seemed to me that the substance of the web resisted water as readily as a duck's back."

Since writing the above, a third brief reference to the spider's-web fish-net has come to light. In 1913, Captain C. G. Rawling, a fellow of the Royal Society of Great Britain, published in London a work bearing the title "The Land of the New Guinea Pygmies. An Account of the Story of a Pioneer Journey of Exploration into the Heart of New Guinea." His explorations were done in Dutch New Guinea, on the southern side of the western end of the island beginning in 1910 and covering about a year and a half. On page 289 is found this interesting statement:

"The bushes round the camp (at the village at Atabo on the coast) contained large numbers of an immense spider; I do not know its name, but it is well known in other parts of New Guinea. They have soft balloon-like bodies, and spin a web of great strength. It has been commonly stated that these webs are utilized by the natives as fishing-nets, and that large fish are secured, but I am afraid that this is an unsubstantiated yarn. Nevertheless, it is a fact that the children do take the webs off entire by slipping a ring of cane below, and that in them they will carry fish the size of sprats."

In a former *Bulletin* I published a short article on the spider-web fish-net, giving all the accounts then at hand of this interesting fishing aparatus. Since that time, however, some additional data have come to hand and it seems desirable to put these on record, and all the more so because many people have thought the first article a "fish story" and not worthy of credence. The data now to be presented will amply confirm the accounts previously given.

The account in question had its origin in a communication from the distinguished Russian traveller, Miklucho-Maclay, to the German explorer, Kubary, and by him passed on to Louis Becke, the Australian South Sea trader and writer of charming books on South Sea Life and customs. In addition to a search made for me at the time of the writing of the first article through the available publications of Miklucho-Maclay, I have myself made during the past summer a careful search through his bibliography for all titles bearing on New Guinea. The New Guinea papers were all gone through one by one and page by page, but nowhere was there found any account of the spider-web fish-net story as related by Kubary. The record, if any was made, seems to have been lost.

As opportunity has offered during the past six months, notes have been made of unusually strong spider-webs. And interesting in themselves as well as furnishing corrobatory evidence, some paragraphs may well be devoted to such accounts.

As early as 1725, Sir Hans Sloane in his book on Jamaica wrote of a large wood spider which made nets "so strong as to give a man inveigled in them trouble for sometime" and he quotes Jan de Laet that at Cumana there were spiders' webs so strong that considerable force was needed to break them. Laet wrote somewhere in the sixteen hundreds, but I have not been able to verify the citation, nor one from Oyeido to the same effect for the West Indies.

Later on (1745), Wm. Smith records the fact that

on St. Kitts, Leeward Islands, certain huge spiders make such large webs reaching from bush to bush that they are troublesome to pedestrians. He quote Woodes Rogers that at St. Vincent's, Cape Verde Islands, there are found spiders' webs of even stronger texture than those found at St. Kitts. This statement of Rogers' I have not had opportunity to verify by reference to his book.

Jacobs (1844) says of certain large spiders in Mauritius that: "Their webs, nearly as large and strong as small fishing nets, and suspended in the open spaces between the underwood, frequently and seriously retarded our progress."

Of the neighboring island of Madagascar (loq. cit.) quotes from Purchas Peter Williamson Flores and one Keeling, that there are spiders therein which make exceedingly strong webs.

Darwin in his celebrated "Voyage of the Beagle" (1860) notes that at Rio de Janeiro the paths in the forest were "barricaded" with the strong yellow webs of an *Epeira*.

Moseley (1892), writing of the large and strong spiders' webs previously referred to as being found on the Cape Verde Islands, says:

"A large and handsome yellow spider makes large webs of yellow silk everywhere among the bushes. The silk is remarkably strong, and the supporting threads of the web often bend the tips of the tamarisk twigs, to which they are fastened, right down. Either the spider drags on the thread and bends the twig, or the twig becomes bent in growing, after being made fast to."

Turning now to New Guinea, we find D'Albertis in his book on that great island, saying (Vol. II, p. 15), that near the mouth of the river Fly, "A large kind of spider abounds to an extraordinary extent. This insect constructs a web from one branch to another at the height of a man from the ground, by which it causes the greatest inconvenience to those who walk in the island."

In the not far-distant Celebes, Hickson speaks of huge, coarse webs made by large and brilliant colored spiders. While in the nearby Solomon Islands, Woodford (1890) writes of large spider-webs woven across the paths which were so strong that catching him across the face they offered considerable resistance.

Slightly outside the line of this search, but still worthy of quotation, is Douglas Rannie, who, on p. 94 of his "My Adventures Among South Sea Savages," London, 1912, speaks of seeing at Toman Island a bag made of spider's web used by its native owner to carry a small bamboo box. Similarly somewhat foreign to this article but still of very great interest is the following quotation from A. S. Meek's "A Naturalist in Cannibal Land," London, 1913. On p. 123 he writes:

"My natural history notes on this district (inland New Guinea, near the head of the Aroa River 1903), begin with a note on the very curious Saturnid moth found there, high on the hills, which spins its web on communal lines. A number join together to make a huge web which is sometimes two feet and more across. The natives use the web (which somewhat resembles cloth) as a head-dress to keep out the rain. It is perfectly water-tight."

The reader has probably before getting thus far asked himself if large insects may not be caught in these great strong nets, as flies are caught in our country in the weaker webs of our smaller spiders, and in answer to this query the following accounts are given:

Thomas Belt in his "Naturalist in Nicaragua" (London, 1874), writes (p. 108), that: "Here a large spider had built strong yellow silken webs, joined one to another, so as to make a complete curtain of web, in which were entangled many large butterflies, generally forest species, caught when flying across the clearing."

So also D'Albertis (1881, Vol I, p. 385), speaks of a large spider which had made a net under one of his boxes and in it had taken prisoner a butterfly at least ten times its own size.

However, the natives of New Guinea are not content to let the butterflies catch themselves in the spider webs, but actually make nets for the purpose of catching them. Witness Meek (1913, pp. 140-141):

"They capture specimens (of a large hairy butterfly living in the mountains), too, with nets most ingeniously made of spiders' webs. The manner of making these nets was this: With a very fine forked stick the native would make something like the framework of a tennis racquet. This he would run again and again through and through the strong web spun by the big yellow spider common to the bush there. Having thus got some web acrooss the net, I have sometimes seen the natives get a big fat spider onto the frame, then shake him off. As he tried to climb up they would keep twisting the frame and shaking it slightly to prevent him ever reaching it. Thus the spider was made to spin fresh strands for the net."

It should be noted here that these butterflies are so large that the alternative method of taking them is by shooting them with a bow and arrow. They were as large as fair-sized hedge-row birds. From this we can reckon the strength of the net.

The possibility of birds being caught in such large and strong spider-webs has also probably occurred to the reader, and hence the following accounts will be of interest:

For our first reference to this we must go back to Sloane (1725) who says of spiders' webs in Jamaica that they are made of silken threads so strong that they "will stop not only small birds, but even wild pigeons." While for earlier authorities than himself he quotes Jan de Laet, Peter Martyr, and one "Smith of Bermudas" that spiders' webs are known in the West Indies to catch birds as big as blackbirds.

Moseley (1892) records the following interesting occurrence:

"At Little Ke Island (South of the west end of New Guinea) von Willemoes Suhm actually found a strong and healthy glossy starling caught fast in a yellow spider's web, and he took the bird out alive and brought it on board the ship to be preserved."

Meek (1913) says that such nets are used for catching butterflies, as his description quoted above shows, and possibly also for catching small birds.

We now come to the use of spiders' webs for fish nets, and in addition to the data given in the former paper, the following brief accounts are set forth:

Hardy and Elkington in their fascinating book "In the Savage South Seas," London, 1907, describe in detail many interesting methods of fishing, but, in describing the various kinds of nets used, merely note of ours, "Some are even made of a tough spider's web." From this mere statement it is certain that they never saw this net, for had they done so a figure and description would have surely been given.

Van der Sande (1907) states that a spider-web fish-net (such as described by Pratt—see my paper in the *Bulletin* for March, 1918) is not known in that part of Dutch New Guinea explored by him. Likewise Meek (1913) does not think it is so used, and characterizes Pratt's account as a fairy story, though he agrees that such nets "were (used) for prawns or very small fish." He bases his negative conclusions on the fact that a native left such a net made for taking butterflies outside in the rain over night, and when morning came all the stickiness was gone, and consequently was its usefulness for butterfly catching since the threads were glazed all over. However, there is no reason to judge from this that it could not be used to catch fish, and in fact he says that it is so used for taking small fish.

The next references, however, are absolutely positive and corroborating as they do Pratt's account (1906), leave no doubt that such a net is actually used by the natives of New Guinea. It should be stated furthermore that the author to be quoted seems to have had no knowledge of Pratt's book.

Mr. Robert W. Williamson spent some months in the Mafulu district of New Guinea inland from Yule Island and Redscar Bay—these two being the basal corners of a triangle of which Mafulu was the apex. Returning to England he wrote two books, from which the following extract is taken.

In both his books Williamson, after describing a dip net of hand-woven mesh, goes on to say, using the same words:

"The other form (of dip net) is also found on a looped cane; but the loop in this case is larger and more oval in shape, and the netting is made of the web of a larger spider. To make it they take the already looped cane to where there are a number of such webs, and twist the looped end round and round among the webs, until there is stretched across the loop a double or treble or quadruple layer of web, which, though flat when made, is elastic, and when used becomes under pressure more or less bag-shaped."

Before leaving this interesting subject there may be given a use of the spider's web which is intermediate between that described above and that which will be described in full in another and later paper. The account referred to of this use is found in H. B. Guppy's book "The Solomon Islands and Their Natives," London, 1887. On page 158 he writes:

"The following ingenious snare was employed on one occasion by my natives in Treasury (Island), when I was anxious to obtain for Dr. Gunther some small fish that frequented one of the streams on the north side of the island. I was very desirous to have some of these fish, and my natives were equally anxious to display their ingenuity in catching them. They first bent a pliant switch into an oval hoop, about a foot in length, over which they spread a covering of stout spider-web which was found in the wood hard by. Having placed this hoop on the surface of the water, buoying it upon two light sticks, they shook over it a portion of a nest of ants, which formed a large kind of tumor on the trunk of a neighboring tree, thus covering the web with a number of struggling young insects. This snare was then allowed to float down the stream, when the little fish, which were between two and three inches long, commenced jumping up at the white bodies of the ants from underneath the hoop, apparently not seeing the intervening web on which they lay, as it appeared nearly transparent in the water. In a short time one of the small fish succeeded in getting its snout and gills entangled in the web, when a native at once waded in, and placing his hand under the entangled fish, secured the prize. With two of these web-hoops we caught nine or ten of these little fish in a quarter of an hour."

Another use of spider web is that of a lure for fishing with a rod or by trolling with a hand line, a pole, or a kite. The lure is in the form of a miniature tennis racquet with the threads strung or wound over it, or in the form of a loop or mass of cobweb in which the teeth and snout of the fish become entangled. This is especially used in connection with kite-fishing, but as Kipling says, "that is another story," and the data therefor will be given later in another paper.

How Insects Were Named

A LARGE proportion have been named from their methods of movement or action, and a good many from the various sounds they make. This is as one would expect. To the former class we owe such names as fly, flea, beetle, gadfly, spider, grasshopper, spinning-jenny, moth, earwig, louse, and, perhaps, wasp. The fly is, of course, the flerh, or flouter; the flea (Anglo-Saxon, *flēah*) is the flee-er or escaper (flee and fly are originally quite distinct words) and hence the old proverb, "Nothing in a hurry but the catching of fleas"; the beetle is the biter; the gadfly ("breeze," or "cleg," a grey insect very troublesome to cattle in warm, moist summers) goes gadding or rambling about as if goaded; the moth mows or cuts (aftermath is a later cutting of harvest); the earwig is supposed to wiggle its way into the head by the ear; the louse is the creeper; and, of course, the spider (spinther) is the spinner of threads. The wasp ("wops" is the original pronunciation, not yet obsolete) is the weaver, though some would derive it from the Latin *vespa*. These names are all native, characterised by a directness of application common in Anglo-Saxon nomenclature.

Of insects named from their peculiar sounds we have the following: Bee, hornet, cricket, gnat, midge, deathwatch, and bumlock. The last is Burns' name for the black beetle which "humm'd wi' eerie drone" in the ears of the Twa Dogs. It is the same insect which in Gray's Elegy "wheels his droning flight" when curfew tolls. Milton (in Lycidas) curiously enough describes it as grey, makes it female, and gives it a "sultry horn" to wind. The name death-watch is applied to various insects heard (not seen) as they tick out in a death-chamber the last moments of life; of these the commonest is a brown beetle that bores in the wainscot. The cricket emits a creaking sound; the hornet may be named from its horn-like feelers, rather than from the sound it makes; the gnat is said to be so called from a punctuated sound of its wings, and the midge from the muttering sound of a swarm.

Shape, or some particular appearance, has had to do with the naming of such insects as glow-worm, dragonfly, crane-fly or daddy-longlegs, butterfly (from its castings), and clipshear (Northern name for the earwig). The May-fly (a marvellous metamorphosis of the water-scrow) is named by anglers from the time of its ascent out of streams and ponds. From their habitat we have names for such insects as the grasshopper and the fleh-fly (otherwise the blow-fly); from their color the blue-bottle and the green-fly (or *aphis*). The pretty lady-bird is more correctly the lady-bug, a red beetle almost round and spotted with black—named in honor of the Virgin Mary. Cockroach (not a compound) and mosquito (little fly) are both Spanish; the latter is from Lat. *musca*, a fly, the former is a corrupt form of *cucaracha*, a woodlouse, with us a black beetle.—*J. L. R., in the Scotsman.*

Corking Solutions

WHEN corking up solutions from which it is advisable to exclude all the air (developers, etc.), I find that it is a good plan to put a pin down beside the cork and to tilt the bottle so that the pin is uppermost. The air will then be forced out through the passages beside the pin when the cork is pushed home.

On the Essence of Physical Relativity*

By Sir Joseph Larmor, Cambridge, England

In an important investigation recently reported,[1] Mr. Leigh Page has determined an expression for the translatory force required to sustain an assigned varying velocity in an electrostatic system of a certain type, that namely which it has been usual to investigate as a model of an electron in analytical discussions. The expression contains terms involving the acceleration of the system and its time-gradients, but no term involving its velocity except in combination with these other quantities. The application of his formula to which Mr. Page restricts himself is to challenge a result that an isolated radiating system is subject to retarding force from the reaction of its own radiation of amount equal to its velocity multiplied by rate of radiation divided by c^2. The necessity for such refutation is based on the idea that on principles of relativity the velocity of an isolated body could have no meaning. But the formula obtained seems to leave this question as it was; for equally the acceleration of the isolated body could have no meaning; and moreover, though the thrust of the radiation is in this case compensated, the velocity appears to be actually involved in the formula in the same manner as the impugned result would require for this particular problem of a convected electrostatic system, for which the radiation is extremely transient and very slight in the absence of extraneous force.

It has always seemed to me that this subject, which may be described as that of interaction of the æther with uniform motion, though of slight account phenomenally, is theoretically of high significance, in that it is destined perhaps to throw light on the nature of the forward momentum that is convected by radiation, and thence on the intimate dynamical nature of radiation itself and the physical function of the æther. I therefore propose briefly to indicate what I hold, provisionally of course, to be their present trend of knowledge. An adequate survey of this widely ramifying domain, in its various aspects, is difficult to compress, even when concentration and avoidance of detail is the main aim, and is therefore reserved for a communication to the *Physical Review*.

In the first place the plan now customary of regarding an electron as merely an aggregation of differential elements of electricity seems to be far too narrow a foundation for its internal properties, except by way of partial and provisional illustration. If electricity is to be explained as constituted of electrons, it can hardly be a step towards finality to explain electrons as constituted of electricity. On such a view the kinetic reaction of the inertia of an electron presents itself in theory under the artificial guise of a self-retarding force exerted by the electron on itself, as given by Mr. Page's formula; moreover on this order of ideas there is no reason assignable why electricity should be aggregated into electrons at all, unless other forces and constraints extraneous to the electric theory are to be introduced to hold them together.

On the other hand an æther theory demands immediately the existence of electrons as the singularities in its own constitution—like vortex-rings in fluid—which determine its activity; and the electrons had already formed an essential part of electrodynamic theory before they were detected in the free state, and the actual magnitude of their inertia thereby ascertained in comparison with the masses of the atoms of the dynamical elements. As being thus self-subsisting mobile structures, whose interactions with each other at distances great compared with the dimensions of their nuclei are fully known, but whose internal constitution and adjacent influence could only be illustrated and guessed at, their dynamical specification will be most suitably, at any rate most hopefully, expressed in terms of their electric charge, their effective inertia, and their electrodynamic fields of known forms except inside and close up to the nuclei; all else being held in suspense as matter only for provisional speculation. As in the case of the simplest exemplar of a theory of a medium, the hydrodynamic theory for an ideal perfect fluid containing vortex rings or moving solids, this inertia may be aeolotropic; it may even when waves can travel be a function of the velocity instead of being constant. But it is to be the same whether the system which is its seat be moving with acceleration or not. The momentum of the system, of type mv, is not to involve its acceleration; nor is the energy of translatory motion of the body, of type $\frac{1}{2}m'v^2$ where m' may be different from m. Otherwise all existing general dynamical theory would be dissolved. The production of acceleration is ascribed to applied force, which measured by its result as the value of $d(mv)/dt$. The formula for the force required to sustain an assigned varying motion of Mr. Page's special model of an electron does not in this way introduce only v and its acceleration f: the terms in it which involve the gradients of f have no place as yet in this scheme. Some origin extraneous to the electron must be assigned to them. On the æther-theory that cause is the radiation shot out from the electron while it is in varying motion, which convects somehow mechanical momentum away from it into the free state; the backward kick of this momentum acting on the source from which it is ejected is describable as the back-pressure of the radiation, which would of course exert a compensating forward kick on any obstacle, however distant, which absorbs it. However we may clothe our thought in language of relativity, it would appear that this issuing radiation does effectively possess an absolute velocity c, and therefore an absolute velocity of its source also is theoretically determinable from observations made in relation to it; and this seems to explain how it is that Mr. Page's formula for the force on a system entirely isolated can involve the acceleration of this system and its velocity also.

But a complete isolated system travelling with velocity v, when we include in the system all the radiation that has issued to however great a distance from its nucleus, cannot create new translational momentum. Therefore the backward pressure proportional to v of the radiational momentum projected from it namely $-v/c^2.dE/dt$ on this theory, must be compensated by disappearance of forward momentum attached to the source itself. The momentum of the source is mv: its rate of change is $mdv/dt+vdm/dt$; the first term is the usual kinetic reaction of the inertia m it has at the instant; the other term proportional to v is the compensating one here adumbrated. It follows that we must admit change of mass specified by the formula $\delta m=\delta E/c^2$; so that the mass of a radiating body diminishes proportionately to the energy it radiates, except in so far as there is compensation provided by extraneous radiation which it absorbs.

For example, a particle of cosmic dust describing an orbit round the Sun is retarded by its own radiation, but its mass is kept up by the radiation it gains from the Sun; thus there is no compensation to the resisting force in this case, and the particle will gradually be sucked into the Sun, as Poynting in an important memoir showed.

The physical theory of electrodynamics, including optics, would thus, on the so-called classical lines—which can be held to be not yet obsolete, though special problems of expansion or development to adapt them to new experimental discovery are pressing—involve electrons specified in terms of charge and field and inertia, which are the link with matter, and it would involve also free radiation existing in the æther, specified as regards mechanical force by its convected secondary longitudinal momentum, but physically in evidence mainly by the type and energy of its transverse undulations. These are the materials out of which the science is to evolve itself, and the problem is whether that evolution can be gradually effected in a natural and consistent manner, and one which runs parallel with the course of evolution of experimental knowledge.

The true essence of the relativity of external knowledge is that we can investigate a system only in relation to some other system, and the most convenient, perhaps the only feasible other system, has been hitherto the ideal Newtonian frame of reference of space and time; for that is the canonical system so to speak, with regard to which dynamical principles take on an ideal simple form, and it is a system which is being determined with continually expanding precision by the progress of astronomical science.

The special question now in evidence is—Is it now expedient to exchange this frame of reference, corresponding to c infinite, for another far more complex but very slightly different continuum having a finite space-time modulus c ? The more fundamental question is—Are we to assign to either frame dynamical properties, typified by propagation of physical effect in space in terms of undulations sustained by stress and inertia, or are we to assign to it properties solely geometrical and regard all physical effect as merely projected in duration across space? The forms of special unrestricted relativity which have been recently current ultimately demand and perhaps prefer the latter course; and such modes of expression can apparently be elaborated so as to include most of optics, though perhaps in an artificial and unfruitful manner, if we replace the Newtonian scalar corpuscles of light by projected vector elements of fields of potential (not however conserved in value) from which forces would be analytically derivable. Mr. Page's work has improved very remarkably such a scheme of projected influence by showing that, provided c-relativity is postulated for space and time, it is elements of longitudinal electric force that may be regarded as projected from the sources, and are moreover conserved after the manner of *quanta* as they travel onward.

There is no absolute criterion to decide between the two ideals. The first order of ideas has proved itself as the foundation on which the interlaced fabric of electric and optical science has been actually constructed; the other seems to offer as yet only somewhat ingenuous and disjointed though significant expression for certain striking features of recent discovery which the former has not yet succeeded in assimilating, and seems to require us to obliterate the course of evolution of the science or perhaps to retain it as a mere historical survival.

All these modes of restatement of departments of physical science in more expressly relative terms may be comprehended as partial analytic developments of the far wider principle of the purely relational character of our external knowledge, which was advanced and systematically fortified with great abstract force in the general metaphysical domain by Bishop Berkeley; a principle by means of which he passed on to examine the criterion of real objective existence, and one which was well understood in its present aspect by his friends in Yale College nearly two centuries ago.

Thus in these matters we are hardly concerned with refuting any theory, for all are relative; it is fruitless to traverse any proposition, unless we take into account the definitions and context in which it subsists. The question is, as to which scheme of formulation gives as a whole the closest and most expressive representation of the complex of natural knowledge, and affords the most promising clue to its future elaboration and extension. But a choice does not by any means preclude development along other promising but provisional lines for which an interpretation has yet to be found. A main merit of Mr. Page's powerful papers, especially that of 1914, the feature which may be said to constitute them into a theory, is to my mind that they translate the usual so-called classical electrodynamic theory into the order of ideas, formulation under relativity of the c type being an essential feature, that describes physical action in terms of projected entities (which might perhaps even be *quanta*) of various kinds, effecting this translation in more intuitive and fundamental terms than had previously been attained to; and also that by their conciseness and geometrical directness they facilitate that comparison and contrast with the alternative order of ideas which is the essential matter.

*Proceedings of the National Academy of Sciences.

[1] Proceedings of the Natl. Acad. of Sciences 4, 1918, (47-46); *Physic. Rev., Ithaca*, (Ser. 2), 11, 1918, (376-400).

How to Cut Glass Properly

There is much loss in the course of a year through the breakage of glass. It is one of the serious "leaks" in the hardware business.

Sheet glass should always be cut on the hollow or concave side. One can easily tell the concave side by holding the glass up and then glancing down the edge. This slightly hollow or concave nature of the glass is caused through the process of manufacture.

In the manufacture of sheet glass it is first blown into cylindrical form that resembles a huge bottle. This great bottle-like structure of glass, which is from 15 to 20 ft. in length and about 3 ft. in diameter, is cut into sections approximating 5 ft. in length. These sections are split open at one point by drawing a hot iron across. They are then laid on a mould and flattened by means of heat from a coke furnace. It is never possible to make them exactly flat. The sheets are slightly concave.

There is greater resistance on the convex side than on the concave side. This accounts for the cut "running out," and invariably a spoiled sheet if the cut is made along the convex side. It is essential to safeguard against waste that the glass be cut along the hollow or concave side. But it is also very necessary that the cutting tool be kept in good condition. Care should be taken that it does not get dull, or that the bearing in which it runs does not become worn. If the cutter becomes dull it will skip in places. These little skips are danger places that often cause the cut to run out. If a wheel cutter is used the little wheel should be kept oiled. When not in use if it is kept covered in coal oil it will always be in good shape. As soon as it begins to show signs of dullness it should be discarded or the wheel should be replaced. Where a diamond is used it is always advisable for only one person to use the diamond. It is seldom that two people hold a glass-cutter in the same manner. Every clerk who is allowed to cut glass should have cutter or diamond for his own personal use. And he should take good care of it. The breakage of two or three large lights of glass will cause a loss in actual money, equal to the cost of a good many glass-cutters.—*Hardware and Metal.*

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Part of the city on the White Rock—a world of its own

A near view of some of the ancient houses with modern doors and windows

Scenes in Acoma

A Pueblo City of New Mexico

Our wonderful southwest may be likened to the new book that has just come from the printers, many of its pages are still uncut and unread. To read its mystic pages one must forego the pleasures of the transcontinental fliers, and experience the glaring sands of New Mexico and Arizona.

Barely fifteen miles from the glistening steel rails of the twentieth century, as our standard of measurement goes, yet as remote from it as the antipodes, are a people whose history probably antedates the conjectures of our Archeologists.

To see for the first time the wonderful cliffs of Acoma, rising in many strange formations from the level of the surrounding plains, overtopped with a canopy of the rarest blue, brings to mind many of the impossible tales of imaginative fiction, intensified and thrilling, almost beyond the comprehension of modern minds.

Aco is the Indian name for white rock, and their name for the pueblo, Acoma meaning the people of the white rock. Acoma as it is now generally called, is a monument of erosion that has taken thousands of centuries to complete. The top of the Mesa is three hundred and sixty feet high and some seventy acres in extent. From a distance it has the appearance of a gigantic altar of rock, and upon it, seven thousand feet above sea level, live the descendants of the most ancient dwellers in America.

Within three miles of this sky city is the Mesa Encantada (The Enchanted Mesa), a monolithic splendor five hundred feet in height and perhaps a thousand in diameter. This was the original location of their city, and the legends about it are full of mystery and romance, vividly colored by centuries of repetition.

When the Enchanted Mesa was the home of these people it had just one very difficult trail by which its summit could be reached, making it an impregnable fortress. According to legend a terrific earthquake that shook the whole world, razed the only trail, while all the men folks were hunting, and the women working in the fields of the valley below. Only a few children and old women were left on top, to die from starvation, for they could not be rescued.

On stormy nights the wailings and moanings of these unfortunate people can still be heard. They are no doubt due to the strange rock formations against which the winds are blowing, but the Indian believe them to be the spirits of the departed.

For many years it has been a question of debate by archeologists as to whether the top ever had been inhabited, but the question was solved when a professor from the Smithsonian Institution made the perilous ascent, and found many broken pieces of ancient pottery on its summit.

To be acquainted with the legends of these people and then view the strange structures that are their homes, to see the people themselves, to breathe the atmosphere, seems to place one into an unknown world, an existance in a re-incarnation.

The houses are three-storied affairs of sunbaked clay; from the front they look like three giant steps. A few of them have been modernized by having doors cut at the ground level, but most of them still use the ancient method of entrance, a ladder that leads to the top of each step, and then an opening in the ceiling, just large enough for a person to crawl through, is the main entrance. A visitor would literally have to drop in on his host in Acoma Land.

This same system is also used at Taos, the home of America's first apartment house. Instead of three stories however these houses have five, great pyramids

An Acoma Indian—one of the dwellers on the White Rock

of adobe brick, each structure housing a community.

Striking as their homes may seem to us, their conventions and costumes are even more so. Everything that we look upon bespeaks of antiquity, yet woman suffrage, an achievement still in its infancy among her modern sister, has flourished here for centuries, and to an extent that would make Mrs. Pankhurst envious.

The Acoma woman is the master of her house, she owns it and everything within it. When she marries the bridegroom takes her name and the children likewise. She is the boss. If her husband should find his saddle outside of the door of the domicile, after being out on a spree, it would mean to him an absolute divorce.

The women, however, do practically all of the work, the men look after the children and their pride.

The costumes of the maidens are very picturesque, usually quite vivid in color and enhanced by silver ornaments inlaid with turquoise. Some of the latter are quite valuable, being obtained from mines in the vicinity.

The most striking feature of their comely faces is their method of arranging their hair. When a girl reaches the marriageable age, between twelve and fourteen years, she arranges her hair in two large whorls, one on either side of her head. These whorls represent the squash blossoms, the Acoma emblem of maidenhood.

After marriage it is arranged in two pendant rolls, the symbol of the ripened squash, which is their emblem of fruitfulness. Whether or not this symbolism has anything to do with their married life can best be judged from the numerous brown faces that look upon us with wonderment in their eyes from every nook and corner.

These costumes have prevailed for ages, and so have many of their daily tasks. The man of the stone age probably drilled his spear head in the same primitive way that we find the Acoman drilling his turquoise, by means of a bow drill.

The housewife makes her peculiar bread by heating a polished flat stone over the hot embers of a fire. The stone is from two to three inches thick and eighteen inches in diameter. When it is very hot she spreads upon it a thin film of batter, mixed to the consistency of a fluid paste. The heat of the stone bakes it almost instantly, so that in about ten seconds the edges curl upward, and the whole is deftly removed in a roll having all of the appearance of tissue paper.

Strange and primitive as this may seem, let us think for a moment and consider the chef of the twentieth century restaurant making his flap-jacks. Instead of the heated rock he uses the polished steel plate with its gas burners or electric coils beneath, he pours on his batter, and in a few moments we have the pancake. Centuries of time lay between the heated stone and the electric plate, but the principle has not changed.

And thus Acoma has given us a glimpse of America's earliest inhabitants,—in the present day.

The Annealing of Glass

The September issue of the Proceedings of the Tokyo Mathematico-Physical Society contains a paper by Mr. M. So, on some interesting observations he has made in the physical laboratory of the Tokyo Electric Co. on the annealing of glass. In the first instance a newly drawn glass fibre is heated slowly in an electric furnace and its length observed. It increases as the temperature rises, but at a temperature in the neighborhood of 400° C. it begins to contract, and at about 500° C. becomes plastic. Next, when a short cylinder of the glass between crossed Nicols is heated, the interference rings show little change until a temperature of 400° C. is reached, and then widen and disappear at about 500° C. Lastly, when the glass is slowly heated or cooled, the curve of temperature change shows that over the plastic range of temperature there are absorption and liberation of heat, proving that some change of state of a constituent of the glass takes place at that temperature. The first two effects vary with the nature of the glass, and are not exhibited by annealed specimens. The third effect is found in both annealed and unannealed glass.—*Nature.*

How the Indian women carry burdens. The hair arranged in pendant rolls indicates they are married

The Acoma women are probably the original suffragettes of America. They own the houses and do all the hard work

The After-Treatment of Bromide Prints

WHEN a bromide print or enlargement is not entirely satisfactory in quality, usually the best course is to make another, but at the present prices of materials this is not always desirable. Moreover, the print in question may be the best which it is possible to obtain from the negative, and it becomes necessary to do what we can in such circumstances to make the best of what we have got.

When a print has a flat, foggy appearance a slight general reduction will often effect a great improvement, and for this purpose nothing is better than a very weak solution of iodine, which is poured over the wet print and allowed to act until the high lights turn to a dark blue with a slight yellowing of the finer details of the image. This indicates the formation of iodine of silver, which is dissolved, after rinsing, in an ordinary fixing bath. As the odide of silver is less soluble than the bromide, it is very necessary to give sufficient time in the hypo so as to make certain that no further change is likely to take place. The iodine solution is made by putting half an ounce of iodine in a ten-ounce stoppered bottle, covering it with water, and adding crystals of iodide of potassium till solution is complete. This gives a deep brown liquid, of which sufficient is mixed with water to give a rather deep sherry color. It should be used at once, as the solution becomes inert on standing. After well washing from the hypo the image is capable of intensification by any of the methods described later. A method which is preferred by many workers is to use a mixture of iodine and cyanide of potassium, which effects the reduction in one step instead of two, and has the great advantage of allowing local reduction to be done with great facility. In fact, it is quite possible entirely to remove any unwanted portions of the image, even to the extent of turning a solid print into a vignette, heavy skies may be lightened, lights put in upon buildings or foregrounds, and the solid black edges sometimes seen through neglect of masking the negative may be entirely removed without leaving a trace. A very moderate amount of washing, less than is required after fixing, is sufficient after this treatment. It must always be remembered that the solution is highly poisonous, and due precautions should be taken. Much may be done in the way of cleaning up and local reduction by using the well-known ferri-cyanide and hypo reducer, but this sometimes leaves a faint yellowish image after the black one has disappeared. It is, however, very useful, and, of course, quite safe in use. When reducing locally it is advisable to support the print on a glass slab or the back of a dish close to a running tap, so that the print can be rinsed frequently to prevent hard edges being caused by the action of the solution. A common defect in bromide prints is the appearance of a rusty-looking black, which is usually due to over-exposure and short development, or sometimes when there has been correct exposure, to the use of an exhausted developing solution. This may be remedied in two ways, either by intensification with the chromium process or by gold toning. The former is preferable, as not only is it cheaper but such prints are usually benefited by the increased contrast which results. When little intensification is needed the following formula should be used: Potassium bichromate, 100 grains; pure hydrochloric acid, 50 minims; water, 10 ounces. The print will rapidly bleach in this solution, and will appear much as it would if the ordinary ferricyanide and bromide bleacher were used, except that the white parts will be stained a bright yellow. This will disappear with thorough washing, after which the image is re-developed with amidol, when it will change to a pure black color with a slight increase of contrast. Prints so treated are quite permanent, but are not suitable for sepia toning. Another way of curing rusty blacks is to immerse the print in an ordinary gold and sulphocyanide toning bath, as used for P.O.P. In this the blacks gradually become colder in tone, and if left in too long will turn to a slaty blue. The prints should be well washed, but require no fixing. In order to appreciate the change made by either of these methods it is a good plan to cut an old print into halves and to treat one half only; when the two are compared the difference will be clearly seen.

The peculiar manner of dressing the hair represents the squash blossom and indicates that the girl is unmarried

For press work, where permanency is of no moment, weak prints may be intensified with the ordinary mercury and ammonia solutions, which give greatly increased depth and a good brownish black. More permanency can be obtained by blackening with the ferrous oxalate or amidol developers, but no reliance can be placed upon any image containing mercury.

As we have referred to the gold-sulphocyanide toning bath for giving pure blacks on black and white prints, it may be well to point out that its action is very different with those which have been sulphide-toned; with such, a good red chalk color is easily got by simple immersion for the requisite time, followed by fixation in a plain hypo solution.

It may be required to reduce the strength of an over-developed print from a hard negative, and for this the chromium intensifier will be found very useful. The procedure is to bleach and wash as usual, but only to develop to the desired depth, finishing by a second fixing to remove the unreduced silver haloid which had not been required to form the second image.

It is, perhaps, hardly necessary to point out that all the operations we have mentioned may be conducted by gas or electric light, or in weak daylight.

Stress or abrasion markings are very common upon some makes of bromide paper, and sometimes are difficult to move by the ordinary method of friction, either with cotton wool while wet or a soft rag and methylated spirit when dry. In such cases they would be found to yield quickly to a very dilute ferricyanide and hypo solution or a very weak iodine-cyanide reducer. Stress markings may be to a great extent avoided by adding 3 or 4 minims of a 10 per cent. solution of iodide of potassium to each ounce of developer. This addition tends to reduce contrast in the prints, and should not be made when thin negatives are being used. The general chemical fog caused by excessively prolonged development is best treated with weak iodine-cyanide solution, taking care to stop the action before the image itself is attacked; with a very weak solution, which will quickly clear off the developer fog, it takes a considerable time to make any appreciable effect upon the image.—*Brit. Jour. of Photog.*

Utilizing Surplus Explosives

PROF. DE QUERVAIN, the well-known Swiss seismologist, has made a suggestion which deserves the very careful attention of our military authorities and of scientific men in this country. There are at present large stocks of high explosives in every country which cannot be preserved and must be denitrated or exploded. He suggests that fifty tons should be exploded at definite times and under various atmospheric conditions, and that observers in all the surrounding area should be requested to listen for the sound. Prof. de Quervain is discussing the necessary arrangements for making such experimental explosions in Switzerland with the military authorities of that country; and it would be difficult to support too strongly his wish that concurrent experiments should be made in Great Britain. If made in the neighborhood of seismological stations—for example, near Eskdalemuir—the experiments might be of military value. They could not fail to throw far more light than accidental unprepared explosions on the many problems presented by the transmission of sound-waves by the atmosphere. We may add that the Swiss War Office has already presented ten thousand kilograms of lead and steel from its surplus stores for the bob of the new three-component seismograph.—*Nature.*

Production of Alcohol from Algae

LAMINARIA *digitata*, dried to a moisture content of 10%, was heated for ½—1 hour at 122° C., with water containing 3—6% of sulphuric acid. The cooled liquid, brought to an acidity of 0.1%, and sprinkled with brewers' yeast, fermented readily, especially after addition of nitrogenous material, and yielded 6 litres of alcohol per 100 lb. of dry algae. Higher yields might perhaps be obtained under industrial conditions, and the mineral matter in the vinasses might be utilised.—*Note in J. Soc. Chem. Ind. on an article in Comptes rend.*

Sugar from Several Points of View*

By George Martineau, C.B.

(This paper is written to prove, from the history of sugar during the last sixty years:—1. That nascent industries can be encouraged, research stimulated, and efficiency created, by a rational, well regulated, but moderate stimulus. 2. That preferential treatment in home markets is the best, perhaps the only, way to give real confidence to capital; and that with that confidence, coupled, of course, with favorable natural conditions, British industries will flourish, and may even become capable of furnishing the whole consumption of the Empire. 3. That the dumping of commodities below cost price is a fatal injury to the consumer.)

Dr. H. C. Prinsen Geerligs, in his fine work on "The World's Cane Sugar Industry, Past and Present," gives a long and interesting account of the early history of sugar. He goes back to Hindu mythology. A certain famous hermit, once upon a time, was desired by an Indian prince to procure for him permission to be translated to heaven during his lifetime. This was refused, but the hermit kindly furnished for him a temporary paradise on earth. This seems to have included, among its many delights, the sugar cane. After the destruction of this paradise, the sugar cane was spread all over the world as a memorial of the famous hermit. No date is mentioned.

When we emerge from these pre-historic times we again meet with a real sugar, for the first time, in India. It is called "gur" in India now, and that seems to have been its name from very early days.

In the seventh century, A. D., the fact is on record that a Chinese Emperor sent people to India to learn the art of sugar manufacture. The natives in India at the present time are content to produce "gur" by boiling down the juice from the cane till it solidifies. but it appears that even in that early period the Arabs, when they got hold of the sugar cane, learned to purify the raw sugar by re-crystallization and produce a great variety of sweetmeats.

In the thirteenth century travellers reported the existence of many sugar factories in China. Then we hear of the Arabs taking the sugar cane to Sicily, and thence to Africa. Thus it spread all round the coasts and islands of the Mediterranean. The Crusaders found extensive sugar plantations in many parts. Spain boasted of a flourishing sugar industry even in the twelfth century. From China the sugar cane found its way to the Indian Ocean, to Siam, the Philippines, Formosa, and Japan. But in those days it was only in China and the countries round the Mediterranean that a real sugar industry existed. The Crusaders took a great interest in the cultivation of the sugar cane, and founded many important centres of the industry.

When these early industries produced more than they consumed a trade in sugar sprang up. The Crusaders, when they got home, began to import it, and a brisk trade started between the Italian ports and Northern Europe. It is curious to note that in these early days the traffic was in refined, not raw sugar. This is easily explained by the fact that the art of sugar-refining had not yet reached to Northern Europe. It was actually loaf sugar that the Crusaders and others imported from the Mediterranean ports. We hear of Damascus and Tripoli becoming great sugar-refining centres in the fourteenth century.

Then, alas! in the fifteenth century the Turks began to overrun these countries, and the sugar industry had a bad time; in fact, as Dr. Prinsen Geeligs says, "the once flourishing sugar industry of the Mediterranean was condemned to extinction." But, in the meantime, the Portuguese took the sugar cane to Madeira, the Azores, the Cape de Verde Islands, and the Gulf of Guinea. Spain colonised the Canary Islands. In all these places a new sugar industry sprang up and flourished, especially with the help of slave labor. Then came America, Spain, Portugal, Holland, Great Britain, and France colonised a vast territory, and sugar, instead of being a fancy luxury, soon became an article of common consumption. Fertile land, a favorable climate, and cheap labor formed the basis of the great sugar industries of the West. First Brazil, then the West India Islands, English, French, Spanish, and Dutch, then other countries on the mainland of America, Surinam, Demerara, Berbice, and finally Peru, Argentina, Chile, Mexico, and Louisiana. The competition from these new countries soon extinguished the little industry in Madeira, the Cape de Verde, and the Canary Isles.

France introduced sugar cane into Mauritius and Réunion, which soon began to export sugar to Europe. Early in the eighteenth century the Dutch East India Company, which had been importing sugar from Formosa, Bengal, and Siam, introduced the sugar cane into their Island of Java; but the wonderful success of that most remarkable of all cane-sugar industries did not take place till long afterwards.

Then, at the birth of the nineteenth century, came the great war between France and Great Britain, and the cane-sugar industry had a bad time. Naval engagements in West Indian waters, the sinking of sugar cargoes, the capture of merchant ships, not only from the West but also from the East, and other blows dealt by France at British trade, did not conduce to the development of the cane-sugar industry. Finally came Napoleon's "continental system."

I am much obliged to Dr. Prinsen Geerligs for enabling me to give this brief sketch of the early history of cane sugar, and can now go forward to my own personal experiences from 1856 to the present day.

In 1856 our industry of sugar-refining was in a flourishing state. Practically all the loaf sugar consumed in this country was produced in the East End of London, where about twenty refineries, each doing a few hundred tons a week, were very busy, giving work and wages to the surrounding neighborhood, and keeping the London Docks fully occupied with the thousands of hogsheads of West India sugar which were annually imported. That was the sugar which we principally used, helped out with sugar from Mauritius, British India, the foreign West Indies, and the foreign East Indies. The total, in 1856, was 384,000 tons of raw cane sugar, to which must be added 9,000 tons of foreign refined sugar and 4,000 tons of raw beetroot sugar. This gives a total consumption of 397,000 tons. The remarkable point is that of the 384,000 tons of raw cane sugar 285,000 tons, 70 per cent. came from our own sugar-producing British Possessions, East and West, but especially West. Those were good days, not only for British sugar-refining but also for the British West Indian Colonies and Mauritius. It will be interesting, for a moment, to look at the kind of sugar which the world produced in those days, and especially at our largest contributors, the British West Indies.

The British West Indian sugar of sixty years ago was an excellent class of raw sugar, so good, in fact, that a considerable portion of it was pure enough to go direct into consumption, and it is with regret that those who were intimately acquainted with it view its impending abolition. It was well made, with great skill and care, a skill which has probably by this time nearly died out. It was a primitive process, but much superior to other primitive processes of those days, some of which, unfortunately, still survive. It was called "muscovado sugar," and was produced by a simple process, giving a good result when well done, but very different to present requirements.

At the date with which we are now dealing the world produced about 1,200,000 tons of cane sugar and 250,000 tons of European beetroot sugar—total 1,450,000 tons. The cane-sugar producing countries of those days, mentioned in the order of their importance, were Cuba, Java, Mauritius, the British West Indies (including British Guiana), Brazil, Porto Rico, Manilla (the name in those days for sugar from the Philippine Islands), Réunion, Louisiana, and the French West Indian Islands of Martinique and Guadaloupe. The finest raw sugar came from Java, Mauritius, the French West Indies, Réunion, and Louisiana. Cuba made a semi refined raw sugar called Havana, but the bulk of its production was a muscovado sugar, very inferior to the British variety. Porto Rico, on the contrary, produced a very fine muscovado sugar, quite fit for direct consumption. The sugars from Brazil, Manilla, and British India were very low brown impure varieties, requiring a great deal of refining. The British refiners were experts with that class of sugar, while the foreign refiners, in France and Holland, preferred the easier work—mere child's play—with a raw material of a much higher grade, in fact, almost pure.

The British sugar refining industry in 1856 was not confined to London, though London produced practically the whole of the loaf sugar which we consumed. Bristol was a very old-established centre of the industry. The great house of Finzel, then the largest refinery in the country, was celebrated for its large grained crystallised sugar, and was the first to use the newly invented centrifugal machine. Liverpool also was a large contributor to our refined sugar production. Ships from Brazil were constantly arriving in the Mersey and bringing, among other things, the low brown sugar from that country. In the Clyde also a new and flourishing industry of sugar-refining was springing up. It increased with great rapidity, having discovered a new way of producing yellow sugar of very superior color and quality, a kind popular with the buyers of the cheapest article. The history of the rise and progress of this industry is interesting, as an indication of the vicissitudes through which the sugar-refining industry of this country had to pass between 1887 and 1903.

In 1854 the sugar-refiners of Greenock (and Glasgow) imported 50,000 tons of raw sugar. In 1865 they imported 136,000 tons, and the figure went on increasing rapidly until, for the five years 1877-81, the average yearly importation was 248,429 tons. This figure held till 1887, when a fall, as rapid as the rise, set in. For the five years 1887-91, the average yearly imports had fallen to 228,733 tons, for the following five years to 170,373 tons, and for the years 1897-1900, to 124,874 tons, a lower figure than that from which they started in 1865. Presently we shall see the reason why.

This is the completion of our brief sketch of sugar sixty years ago. Let us turn to another picture—after a violent revolution. The last year of the nineteenth century, 1900, was a record year in the history of sugar. Our consumption had risen from 397,000 tons to 1,624,000 tons—more than four times as much. That is a wonderful fact, but another, far more incredible, comes next, namely, that out of this enormous quantity of sugar consumed in the United Kingdom only a little scrap, 129,000 tons, was produced from the good old sugar cane. Even that small quantity would not have come to us had it not have been for two facts—first, that our Colony of Demerara produced a very choice kind of yellow crystallised sugar which a few intelligent connoisseurs insisted upon having; and, secondly, because two of our sugar-refining firms stuck to cane sugar, hoping to obtain a fancy price for their refined sugar. We hope they did.

But there is one more almost equally incredible fact to be revealed. The world's production (not including the imaginary figure for British India, which now confuses our statistics) had increased from 1,450,000 tons to 8,291,800 tons—nearly six times as much. Now comes the most wonderful fact of all. Of this quantity, only 2,880,900 tons was the product of the sugar cane—less than 35 per cent.; in other words, nearly two-thirds of the world's production of sugar came from the beetroot fields of Northern Europe and, to a small extent, from the beetroot fields of the United States. These facts are worth looking into, in order to discover causes for such startling facts. I could spend several hours in explanation—all of it interesting—but we must be brief.

There is no need to go into the history of the origin of beetroot sugar here; suffice it to say that Napoleon Bonaparte had something to do with it, and also the King of Prussia. I said in 1856 Europe produced about 250,000 tons of beetroot sugar. That was doubled in ten years, and in five years more the production exceeded a million tons. Another ten years raised the figure to two millions. This brought cane and beet neck and neck in the race; then beetroot shot ahead to three, four, five, and six million tons.

There are two causes at the bottom of this mystery. Energy, ability, efficiency, and, more than all, persistent research, constituted the first and best cause. But this best cause is not to be had, as a rule, unless you give it a stimulus. Capitalists do not care to risk their money unless they can see very clearly that there is some security for their investment. That is exactly what the European beetroot-sugar industry enjoyed; all except France, who had to languish till 1884. France gave the research most liberally, but she lacked the stimulus.

It was Germany that hit upon the right kind of stimulus. It was a brilliant idea, quite an inspiration, and was carried out with great judgment. The sugar duty was levied—not upon the sugar produced, but upon the roots. This at once stimulated the farmer to produce the richest possible quality of root, and the manufacturer to extract from the root the largest possible quantity of sugar. Great pains were taken to breed an improved variety of sugar beet. This great research lasted for years, and still goes on. Its success was astounding—incredible. At the beginning the sugar-beet contained less than 6 per cent. of sugar. In France it continued to contain less than 6 per cent. of sugar until the stimulus was applied in 1884 to save the life of the industry. But in Germany the roots went on, year after year, increasing in richness until, in 1908, the average quantity of sugar actually extracted from the roots for the whole of Germany was 17.63 per cent. I used the word "incredible," and it is the only word to use. The natural quantity of sugar contained in the sugar-beet had been multiplied by three. For the ten years 1899-1908, the average yield for the whole of Germany was 15.49 per cent. This shows what can be done by giving a rational and very moderate stimulus. That this wonderful result was caused by the stimulus—plus, of course, great efficiency—is proved by the lamentable fact that poor France, who received no stimulus till 1884, was at that date getting a yield of less than 6 per cent. of sugar, while Ger-

*The *Chemical News.*

many at the same time was producing 11 per cent. of sugar from the roots as the average for the whole country. France hastened to adopt the German system, but never succeeded in catching it up in the race. The average yield for the ten years 1899-1908, which, as I have said, was 15.49 per cent. for Germany, was only 12.84 per cent. for France. This is the worst of being "too late." In industry it is fatal. Austria, with a system similar to that of Germany, got a yield of over 15 per cent. for those ten years.

Research was still rampant, and the breeding of the rich roots led to the invention of the diffusion process—another result of the stimulus. This process now brought to great perfection, practically extracts the whole of the juice, and in a very pure state. In my book on sugar I gave the results of a good German factory in 1908, from which it will be seen that the average quantity of sugar contained in the roots worked by that factory throughout the season was 17.10 per cent. and that the quantity actually extracted was 16.64 per cent. These figures show what can be done when efficiency reigns supreme, and they are also a good illustration of the perfection to which chemical control of a sugar factory can be brought. Everything that happened is known, down to the second place in decimals. France, so long as she worked roots containing less than 6 per cent. of sugar, could not attempt the diffusion process.

Another instance of the valuable results of research is the multiple evaporator, called by the French the "Triple Effet." The French had a considerable share in bringing this invention to a practical success. It has enabled the sugar factory to perform the most important and expensive part of its process—that of evaporating the thin juice till it is thick enough to crystallise in the vacuum pan—with the lowest possible expenditure of fuel. Research is still going on with regard to this part of the process, and has not yet said its last word.

Greatest of all the results was the gradual development of the new method of purifying the juice, called the double carbonation process. We have no time, on such an occasion as this, to describe processes, but I can safely assert that this must be regarded as one of the greatest of all the results of the researches of the last fifty years in the world of beetroot sugar. It has now found its way to Java, where fine white sugar is being produced in large quantities by means of it. But here again there is no finality, and it is quite possible that a still better process, giving equally good results at less expense and trouble, may eventually take its place. Research is still busy with it.

The great cane-sugar industries of the world did not take a *laissez-faire* view of the subject. They immediately buckled to and set their house in order. They at once adopted the multiple evaporator, and now every modern factory has one, or perhaps several. The diffusion process was tried, but found to have too many drawbacks when applied to cane-sugar production; but they were determined to try to extract if possible nearly the whole of the juice in the cane. Instead of having only one three-roller mill, which squeezes the cane twice, they now have four, placed tandem fashion with travelling bands between, and thus give the cane eight squeezes. They also place two rollers with rough surfaces at the entrance to the first mill, which crack the hard crust of the cane before it enters the mill. With these improvements and "maceration" of the "megass" (the crushed cane) in its transit from mill to mill, they now extract 95 per cent. of the juice, and are ready to fight the beetroot industry. Instead of hundreds of tons, they are turning out thousands from each factory, and thus reducing cost of production. They have, however, their own special difficulties to surmount. Labor is one of the greatest. Here Java is in a favored position. She has also good soil and climate, great efficiency in management, and a fairly good system of irrigation. The necessity of supplying the cane with sufficient water is vital, and water is not always attainable.

The cost of production depends, to a great extent, on the quantity of canes per acre which can be produced. Java produces more than forty tons as an average for the whole of the island, and can therefore produce sugar at a very low cost, all the factory arrangements being thoroughly efficient. Half of Java's crop of about 1,500,000 tons (rapidly increasing) is now produced in the form of white granulated sugar of high quality, which goes to British India for the benefit of the upper classes. Our Colony of Mauritius is doing the same, and deserves to succeed after all the cruel troubles she has gone through. White sugar direct from the beetroot juice has been produced for a long time. The present writer recollects seeing one beetroot factory in Germany, as long ago as 1871, turning out good loaf sugar; and at a later date he saw Eugen Langen, the inventor of the cube-sugar process, producing very fine cubes at his factory at Elsdorf direct from the beetroot juice.

This great effort of the cane-sugar industry to compete with beetroot brings us to another striking result of giving industry a stimulus. I have shown how the German stimulus, rationally applied, led to greater efficiency, profound research, and most astounding results. I have compared it with the sadly backward state of the same industry in France, so long as it received no stimulus. And yet I find, if I consult a recent utterance of the Council of the Manchester Chamber of Commerce, that industries receiving such a stimulus are bound to become "apathetic and inefficient." Very well, I have given facts of practical experience in flat contradiction of this doctrine—a doctrine by the way which the members as distinguished from the Council, of the Manchester Chamber have now, I am glad to see, repudiated most emphatically.

I will now give more facts of practical experience, this time from the cane-sugar industry, which again will prove conclusively that this doctrine, so glibly repeated as if it were an axiom, is an absolute delusion. The United States of America gave preferential treatment in their own markets to sugar produced in their own states, territories, and dependencies. They also gave a slight preference—rather more than half a farthing a pound—to their *protégé*, Cuba. Let us see what has been the result of this preference—absolutely inappreciable to the consumer. Cuba, before the Spanish-American War, just succeeded in producing a million tons of sugar per annum in the years 1894 and 1895. After the American occupation in 1898, and when the unfortunate industry had succeeded in recovering from the devastation of the war, the stimulus of the small preference began to tell. In 1903 Cuba got back to the million ton figure. In 1913 it produced 2,500,000 tons, and last year it would have produced 3,500,000 tons, but, unfortunately, when the sugar was badly wanted, an insurrection broke out in the eastern part of the island, and the actual production was reduced to 3,000,000 tons. This enormous increase was the result of the security capitalists found in the small American preference. Large factories were erected, railways connecting them with the shipping ports were constructed, everything was done in the most up-to-date style, and the only trouble was to get the sugar sold and shipped as soon as possible. The United States markets were glutted during the thickest part of the crop time, and prices went down sometimes more than £2 per ton below the European level. The American consumer actually gained by the preference.

In Cuba at the present time there are many factories that turn out from 10,000 to 20,000 tons of sugar per annum. There are about the same number which turn out from 20,000 to 40,000 tons. There are eight that turn out from 40,000 to 60,000 tons. There are three that turn out from 60,000 to 80,000 tons. There is one that produces between 80,000 and 100,000 tons, and there is one that produces more than 100,000 tons per annum. This is the "apathy and inefficiency" created by giving a preference!

The greatest research now going on in the cane sugar industry is the breeding of new varieties of cane which shall give more sugar, resist disease, and be suitable for various soils and climates.

I will conclude by giving one more instance of the results of preferential treatment in the home market. We know from recent experience how comfortable it would be if we could produce enough sugar for our own consumption without going to foreign countries for it. The United States is now in that happy position. Since the preference was granted Louisiana has increased her production from 95,000 to 414,000 tons; domestic beetroot from 1,000 to 779,000 tons; Hawaii (the Sandwich Islands) from 12,000 to 602,000 tons; Porto Rico from 50,000 to 400,000 tons; the Philippine Islands from 92,000 to 300,000 tons; and, finally, Cuba from 1,000,000 to 3,500,000 tons. If America had not created this great increase in production by giving a preference to her own family and friends we should at the present moment be suffering—and so would America—from a real sugar famine. Instead of that what do we see when we turn to American statistics for 1915? In that year the consumption of sugar in the United States amounted to the large figure of 4,257,713 tons, every ounce of which, with the purely accidental exception of 23,000 tons, came from her own states, territories and protectorates. This striking fact is entirely the result of giving a preference. The United States, so far as sugar is concerned, is now independent of the outside world, and is even able to spare us a million tons from Cuba whenever we are short of supplies.

This ends my essay. There is another essay that might be written from the opposite point of view, showing the injury done to our sugar industries by competitors armed with an artificial stimulus. I have dealt with that, and with the economic questions connected with it, in a little book entitled "A Short History of Sugar, 1856-1916, a Warning," to which I desire to refer my present audience. But as I made a passing reference to the injury done to our refining industry, as illustrated by the serious reduction in the industry on the Clyde from 240,000 tons per annum in 1882-86 to 125,000 tons in 1897-1910, it is necessary to point out that the cause of this collapse was the enormous importation of foreign refined beetroot sugar, at prices with which the unstimulated producer could not compete. For many years nearly a million tons were imported every year, the sugar being landed at every little port around our coasts. The Brussels Convention came into force in 1903, and the Clyde industry, which can work as cheaply as any refining industry in the world, revived. In 1913, the last year before the war, the Clyde refiners melted 231,333 tons, nearly as much as at the height of their remarkable prosperity in 1877-1886.

A distinguished—shall I say economist?—has recently proclaimed that "the millions should not be deprived of cheap sugar even if it be dumped." To this most attractive exclamation there are three most conclusive contradictions, founded on facts derived from the history of sugar during the last forty years. Those facts prove—first, that the fleeting pleasure of buying a commodity below cost price is disastrous to the consumer, because it is bound to be followed by reduced production and higher prices. Secondly, that under such circumstances the stimulated industry again takes the lead, increases its production, forces down prices once more, and gets one step further on the road to monopoly. That is exactly what happened to sugar. Thirdly, it is a fact that the millions have never been deprived of cheap sugar, except when there happened to be a bad beetroot crop, which is a periodical occurrence. Then prices go up. The dumped sugar, in which the consumer revelled, has made him more and more dependent on the beetroot crop for his supply; when that fails he has to pay the penalty. Then the war broke out, away went the whole of his dumped supply—and now, he is on rations.

These are the conclusive answers to this profound economist. He should begin by trying to master the rudiments of his subject.—*Journal of the Royal Society of Arts*, lxvi., 474.

Pinholing and Peeling on Terra-cotta

"PINHOLES" are caused by small tongues of underslip which rise through the glaze and leave a clean hole with a distinct projection. They are not merely small blisters or holes in the glaze. Pinholes are produced when a second coating of underslip or a coating of glaze is sprayed on to dry terra-cotta, when no barium salt is added to a body containing soluble salts, when an excess of barium carbonate is added to the clay, and when the dry ware is brushed over with a 10% solution of barium chloride or fluoride previous to slip-coating and glazing. In the case of all glazed ware, pinholing is worse in glazes which flow least in firing. Pinholes are not prevented by rubbing the dried and glazed surface, by avoiding the use of oil, or by brushing away all dust before coating the ware. They are not caused by particles of plaster from the mould or by the slip- or glaze-coatings being too dry before a further coating is applied. They are partially prevented by removing the surface of the ware with sandpaper, by firing the underslip with no glaze covering, and by adding 2% of a mixture of barium carbonate and fluoride. They are wholly prevented or remedied by re-spraying the burned pieces with glaze and reburning or, preferably, by adding 2% "gum arabic sorts" to the underslip and 3% to the glaze.—*H. Wilson, in Trans. Am. Ceram. Soc.*

Determination of Oil in Seeds

For extraction of the oil from oil seeds Kreussler's apparatus is more satisfactory for use with ether than Soxhlet's apparatus, only a few c.c. of the solvent in excess of that needed to saturate the sample being required. Small seeds can be completely extracted in about 2½ hours, while palm kernels, copra, etc., require 8 hours. In the case of coarsely ground material the sample should first be extracted for 4 hours, then ground in a mortar, and the extraction continued for a further 4 hours. Thorough drying of the seeds before extraction is essential to prevent extraction of gum resins from the husks. In the case of drying oils the residue left on evaporating the extract should be dried in a current of dry hydrogen, coal gas, or carbon dioxide.—*Note in J. Soc. Chem. Ind. on a paper by W. B. Gray, J. S. African Ass. Anal. Chemists.*

"Blue Coal"

Utilizing the Energy of Waves and Tides

THE expression "white coal" applied in Europe to the energy derived from the glaciers found in Switzerland, Norway, and elsewhere, has become well known in this country. Less familiar are the terms "green coal," signifying the power derived from streams, and "blue coal," referring to the force exerted by the waves and tides of the ocean.

This last is undoubtedly the greatest source of terrestrial energy known to man, and many and various have been the efforts to tap its vast stores of power.

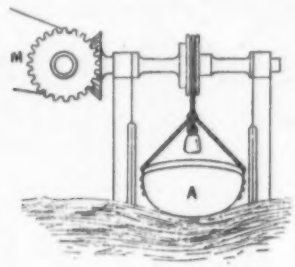

Fig. 1. Wattson patent

The boat A transmits its rising and falling motion to the shaft M by a gear wheel.

The problem is difficult enough yet now that that other riddle of the ages, the art of flying, has been so gloriously solved, there is reason to hope that man's industrial future may be transformed through the utilization of the forces now so prodigally expended on our shores.

A late number of *Larousse Mensuel* (Paris) offers a timely exposition of the efforts which have been made in this direction, from which we take the following:

In this study we propose to set down the data of the subject, to describe various efforts to solve the questions involved, and to deduce the results of this new adaptation of energy.

Movements of the Sea.—The mass of water constituting the seas is in a state of continual agitation. Some of its movements are rythmical in character while others consist of simple displacements in a definite trajectory; the latter constitute marine currents with which we do not here propose to deal.

The rythmical motions are of two kinds, varying in the interval of their repetition. Those which have an undulatory movement of short period form *the swell* and *the waves*, while where the amplitude of the interval amounts to several hours the phenomenon of the tides is produced.

The swell is the manifestation of an undulatory disturbance in the sea comparable to that produced by throwing a stone into a body of water. Around the focus of disturbance a series of concentric circles is formed which appear to recede into the distance. In reality the molecules of water undergo no lateral displacement; they vibrate in a vertical plane following a closed curve, a sort of much elongated ellipse.

In calm weather the surface of the sea presents these alternations of rise and fall. This is the phenomenon of *the swell*. If the wind, which by the friction of the air on the surface of the globe rises, the swell is modified, the sinusoidal curve is folded and its highest points form a crest; but very soon, because it lacks support, this crest rolls over, allowing the air which it imprisons to escape in its fall; the wave has had its birth. This time the water is displaced, driven before the wind, and the wave often attains considerable speed.

The surface of the waters may be disturbed by a primary system of waves, but the latter, in hurling themselves against the coast, for example, give rise to a new series of reflected waves whose period and amplitude may differ from those of the first; they conflict with the former, either augmenting them or opposing and annulling them. This interference of waves constitutes a "choppy" surface which is very unpleasant for navigators. Such chopping is found in bays, where the reflection of the waves from the shores is facilitated.

Finally, if the wind becomes violent waves acquire an almost irresistible force; their height sometimes exceeds 16 meters (52 feet) and their speed of displacement 42 kilometers per hour (26 miles). A wave 10 meters (32½ ft.) high and 100 meters (325 ft.) long represents an energy of 2,000 h.p. per running meter. It is easy to comprehend the destructive force of such a mass of water striking the cliffs several times per minute with pressure of 30 tons per square meter. A west wind driving waves against our shores exerts a continuous force of a hundred million horse power.

The movement of the tides, on the other hand, is very regular, on our shores, for instance, the tides rise at an interval of 12 hr. and 25 min., and at times which vary according to locality and the time of the year, attaining their culminating point—high tide—in about 6 hrs. They hold this a few minutes and then begin to ebb. The tides bear a direct relation to the attraction of the sun and moon upon the sea; this attraction occasions the oscillation of the liquid mass of the globe, with the formation of waves; these may combine to form the highest swellings observed. The speed of displacement of the tidal wave is directly proportional to the breadth and depth of the ocean. It varies with the obstacles encountered en route, islands, reefs, continents. Without going into details it is enough here to remark that in the open seas the amplitude of the tide does not exceed 1 meter (3¼ ft.) while in gulfs and straits, where different waves of the tide may interfere and be conjoined, it sometimes runs as high as 14 to 15 m. (45 to 48 ft.), as in the Bay of Mont Saint Michel. The speed of the rise depends upon the distance from the sea; in this bay just cited, at the period of high tides it rises as swiftly as a galloping horse.

These two marine movements give rise to two kinds of methods of capturing ocean energy: 1. Those utilizing the oscillation of the swell and of the waves. 2. Those employing the movement of the tides.

I. *Utilization of the Ocean Swell and of Its Waves.*—

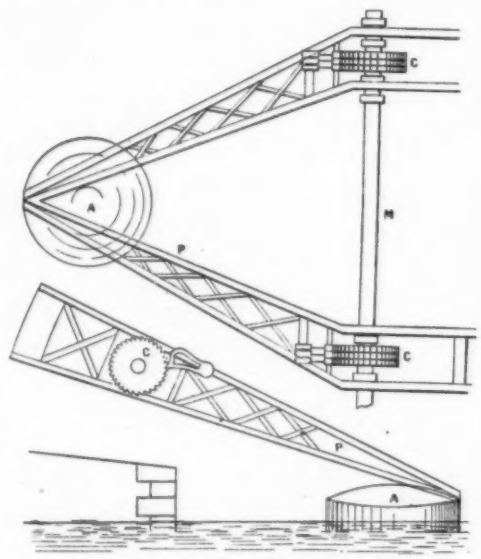

Fig. 3. Fusenot system

A, free floats transmitting their motion by the beams P to the shaft M, by means of the ratchet and wheels C.

The utilization of the wave has the advantage of furnishing a permanent force; it encounters, however, certain difficulties, chief among which is the destructive power of the sea. An installation which works perfectly when there is a calm swell is dislocated and put out of commission in a moment on a day of storm, whence the necessity of extremely strong apparatus.

The oscillation of the swell is most frequently utilized by means of *floats;* these, lifted by the surge of the swell, fall of their own weight, the fall setting in motion a transmission axle. The float may be a firmly anchored boat capable of displacement only in the vertical direction, being immobilized laterally by means of piles; this boat is either held by a rope wound on a pulley which it causes to revolve by its oscillating movements (Wattson Patent, Fig. 1), or else furnished at both ends with jointed levers and toothed racks, acting on a toothed wheel (Berretti hydromotor, Fig. 2).

With the object of avoiding the lifting by the float of the weight of any mechanism whatever, since the resistance thus occasioned might annul the power sought to be acquired, Fusenot (Fig. 3) employs a series of cylindrical floats, free to rise vertically, their movements being transmitted by balanced stop-planks, carrying catches, to a ratchet wheel, each oscillation causing the displacement of one tooth of this wheel.

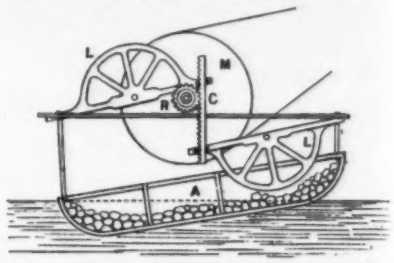

Fig. 2. Diagrammatic arrangement of Beretti system of floats

A, float causing the wheel M to turn by means of the levers L, the toothed racks C and the cogged wheel R.

Dr. Legrand, the author of an interesting plan for capturing energy which is detailed farther on, has proposed a special form of float for the utilization of waves, a sort of large buoy sliding on a vertical shaft movable around a point of suspension situated in its upper portion, the whole constituting a sort of pendulum, of which the buoy forms the pendulum bob. The play of the buoy, lifted by the surge of the swell and displaced by the wave, causes the oscillation of the pendulum. A special device transmits this motion to a pneumatic motor. This system which is very strong, is admirably suited to installations on the coast, and would be of the greatest service to agriculturists and manufacturers situated on the littoral. Whether constructed in larger dimensions, or whether operated by a combination of several sets of apparatus this pneumatic pendulum permits the obtaining of a considerable amount of motive power for the production of electric energy.

Besides the float, other processes may be applied to the capturing of the force of the swell; at Nice, for example, the observation of waves shows that the oscillation of the sea represents an average of 10 waves per minute, hurling the water against the beach with an average speed of 7½ meters per second. These waves climb the slope to a height of from 1 to 3 meters (3 to 10 ft.), with an average wave thickness of 1.6 meters (4.2 ft.). These observations suggested to an officer, Mr. A. Maurel, the creation of stations for capturing energy established in the folowing manner:

In these stations the wave in breaking penetrates a walled channel ending in a closed chamber whose stage is provided with turbines; the water which enters this chamber cannot escape through the exit channel except by traversing these machines (Fig. 4). In this arrangement, with entrances 12 meters wide (39 ft.) and utilizing a sheet of water 2 meters (6½ ft.) above the level of low water, it would be possible to establish by means of 8 turbines, stations yielding 5,000 h.p. working day and night.

The variation of the pressure of the air contained in an enclosed space into which the sea penetrates, which forms the basis of various processes for utilizing the tides, as we shall see further on, may find an application in the utilization of waves. A plant conceived along these lines is in operation near Royan. The inventor, Bonchand-Praceiq, utilizes as the generative element a vast air chamber formed by a well and a perpendicular tunnel connected with the sea; the water, freely penetrating the tunnel, compresses or expands the air contained in the free space of the chamber; this air, compressed or expanded according to the oscillations of the wave, acts upon the blades of a sort of aerial turbine, arranged to turn in the same direction, whatever the direction of the current of air may be.

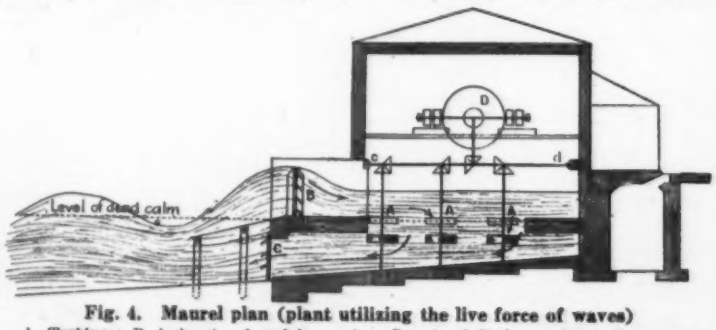

Fig. 4. Maurel plan (plant utilizing the live force of waves)

A, Turbines; B, lock-gate of arriving water; C, gate of discharge sluice; D, apparatus of utilisation; c d, power shaft.

II. *Utilization of the Tide.*—The phe-

nomenon of the tides being regular, and the energy of the sea here considered not being emitted with the violence of waves, its employment is theoretically easier.

The various systems employed may be divided into two classes:

1. Systems utilizing *open basins*, full or empty according to the state of the tides, and employing *water* as the motive agent for setting in operation the wheels or turbines;

2. Systems utilizing *closed basins*, in which the

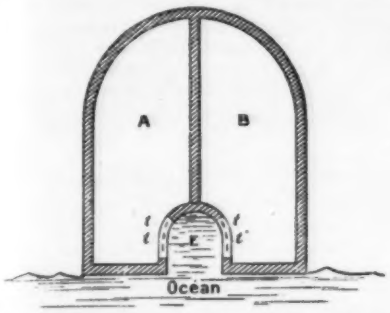

Fig. 6. Arrangement of basins in Diamant system
A, B, basins; E, basin open to the sea; t, t', turbines.

motive agent is the *air* compressed or rarefied according to the movements of the flood.

Open Basin Systems.—These are the more numerous of the two; some of them indeeed include actual installations. In its simplest form the system comprises a basin which is filled at high tide, and empties itself as the sea falls, the enclosed water pouring into some sort of hydraulic apparatus (wheel, turbine, etc.); such is the *tide mill*, some types of which are found on our Breton coasts. According to this conception the mill furnishes but a very imperfect solution to the problem; it has the merit of being not very costly, but the serious fault of working only at irregular intervals, sometimes by day and sometimes by night—conditions quite incompatible with any important industry. For this reason the improvements sought have had in view the construction of apparatus which should be regular and continuous.

On May 12, 1890, Decoeur, engineer of roads and bridges, proposed to the Academy of Sciences, with regard to the management of the estuary of the Seine, the creation of vast basins for the continuous storing of the energy of the tides. He had in view two consecutive basins, one filling itself at high tide, the other remaining empty; the stored up water could later pass from the first basin to the second through openings situated in the dividing wall, and containing turbines, the water from the second basin being later discharged into the sea at the time of the receding tide.

If the basins are spacious enough a sufficient difference of level may be maintained between them to insure the regular functioning of the turbines during a period of time at least equal to that required for the refilling. This idea has been employed in a recent patent by an American. This inventor, whose device we reproduce (Fig. 5), regulates the arrival and the departure of the water in his basins by means of retaining gates placed in the dikes separating the basins from the sea; these gates open inward for supply and outward for discharge. They are so constructed as to close by their own weight when the pressure becomes equal on their opposite faces.

In these systems one of the basins is an accumulator of water, the other serving simply to discharge the water which issues from the turbines. It is possible to arrange them to work alternately, the turbines in this case being placed in the dike which separates the basins from the sea.

The first basin, supposing it to be full, empties itself during the falling tide, at the same time setting the turbines in motion until the moment when its level is nearly that of the sea. At this instant the second basin comes into play and helps the crossing of the dead point; various methods of managing the apparatus have been published.

Diamant, of Melbourne, attains constant functioning by establishing two equal basins, A and B, having access to the sea by a small intermediate basin E, the turbines being placed at *tt'* in the walls of the latter (Fig. 6).

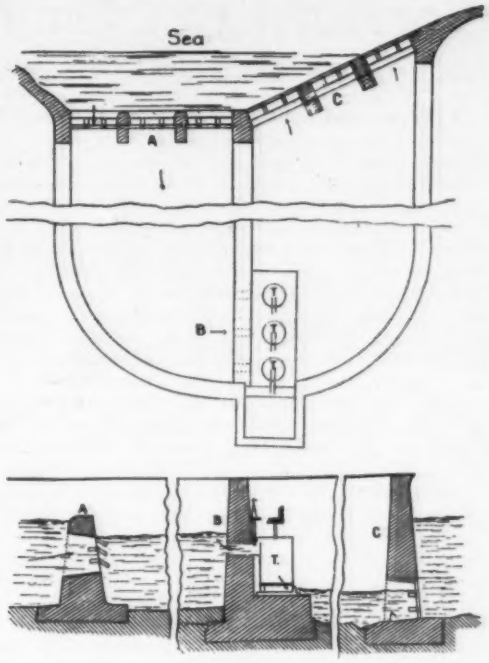

Fig. 5. Gustafson device
A, wall furnished with entrance gates; B, feeding of the turbines T; C, wall furnished with low tide discharge gates.

Let us suppose high tide at an elevation of 12 meters, for example, A being filled; when the ebb occurs the water in this reservoir is retained until the sea reaches an elevation of +9; at this moment it is allowed to flow towards the sea, passing through the turbines with a fall of 12 — 9 = 3 meters; this discharge is continued, being regulated to keep the water in A up to the number —4, during the time required for the tide to become low (O elevation) and to rise again to + 3. It is evident, therefore, that the difference of level is not sufficient to feed the turbines. B. then begins to function, this basin being empty and the sea at + 3. The turbines, traversed by the water flowing in, begin to function under a fall of 3 m.; the operation is continued, being regulated in such a manner as to fill B up to an elevation + 8, in the time required for the flood to reach + 12 and fall again to + 9. The difference of the elevations being then no longer sufficient, A, which has filled meantime, begins to function once more, and the cycle recommences.

This same mode of utilization can be employed during the filling of A and the emptying of B, either by making use of another set of turbines, or by arranging the arrivals of water in a consecutive series; the power of the plant is thus doubled. But it must not be forgotten that the height of the fall must be

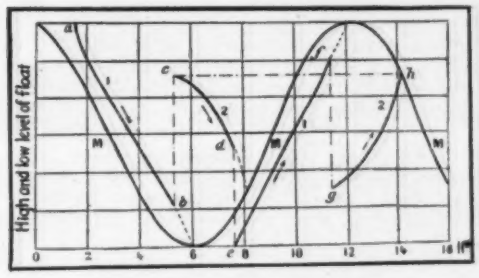

Fig. 7. Esnault Pelterie plan
M, curve of sea levels. 1. Operation of first basin. 2. Operation of second basin. (The difference of level between the basin and the sea represents at any given instant the height of the fall which causes the turbine to work.)

kept constant to insure good working of the apparatus. This can be achieved by making the turbines move in a vertical plane, by installing them on the platten of a hydraulic press in proper relation to the height of the flood. The well known inventor, R. Esnault-Pelterie likewise uses, in order to cross the dead point of the tide, a system of two basins whose method of operation is shown in the diagram (Fig 7). Each basin works either when filling or when emptying, so long as the difference of level between it and the sea is sufficient; for example, from *a* to *b*, the first basin is emptying itself; from *c* to *d* the apparatus is operated by the second reservoir; from *e* to *f* the first basin begins to work again while filling itself; then, from *g* to *h* the cycle is completed by the second basin finishing filling itself; the cycle thus begins anew, the second reservoir acting only as an auxiliary of the first. In this wise the turbines constantly receive enough water to make them function in a regular manner. A certain device causes their speed of rotation to vary as a function of the speed of flow of the water.

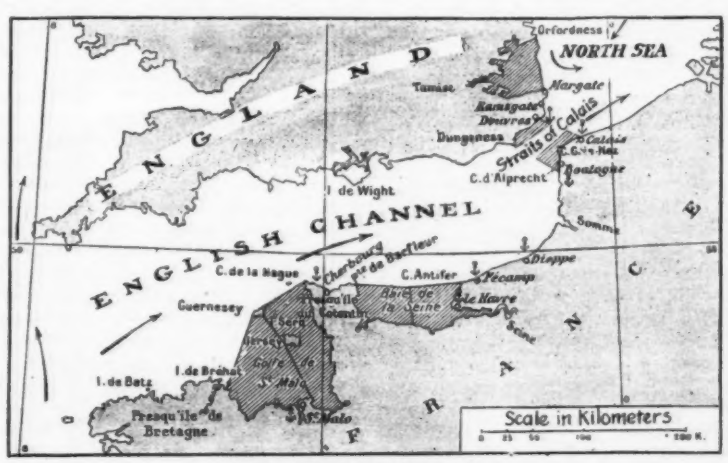

Fig. 8. Esnault Pelterie plan
Arrangement of the strait of Calais and the English Channel with the object of storing up the force of the tides. The arrows indicate the direction of the tides. The cross-hatched spaces represent the storage basins.

Esnault-Pelterie proposes to apply this system to those long, narrow arms of the sea turning from east to west in which the tides attain their greatest height; the case, for example, of the Straits of Calais and the English Channel.

In a projected plan which is grandiose and worthy of the importance of the power to be captured and stored, the inventor forms his basins of vast marine spaces enclosed by walls of reinforced concrete. In the strait of Calais one of these basins would be formed between two dikes barring the strait from Calais to Ramsgate, on the north, and from Cape Alprecht near Boulogne to Dungeness on the English coast, on the south; the other being the estuary of the Thames walled in from Margate to Orfordness (Fig. 8).

The shallows which are numerous in these regions would serve as seats for the dike, and the latter, in order to avoid elevation of the tides and the inundation of the neighboring ports, would be constructed so as to be submerged at the period of the highest tides; a superstructure would support railroads, electric plants, etc., which might be erected there; turbines placed in a canal running along the dike would receive the water coming first from the sea and then from the basin; special gates would regulate these admittances; finally, locks would permit the free movement of ships.

To increase still more the captured power—for the tide of the strait is only a wave resulting from the tides of the ocean, disturbed by the sinuosities of the French continent so as to undergo a sort of return in the direction of its propagation, coming from east to west in the straits of Calais, and suffering consequently a diminution of its force—the inventor proposes to regularize the propagation of the wave by suppressing the action of the gulfs.

The bay of the Seine (from Barfleur to Cape Antifer), the gulf of St. Malo (from Cape La Hague to the

(Continued on page 160)

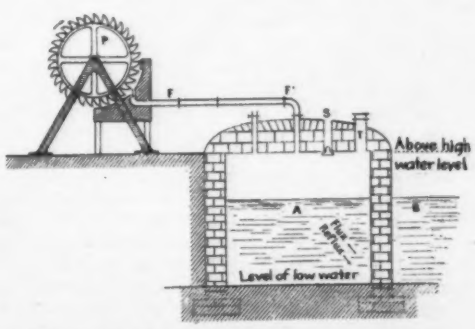

Fig. 9. Dr. Legrand's hydropneumatic motor
A, cistern; B, communication with sea; T, man-hole; S, valve; F, F'; air conduit; P, hydropneumatic motor.

The Seasoning of Lumber*

Basic Facts Underlying the Artificial Drying of Forest Products

By Prof. Bror L. Grondal, of the College of Forestry, University of Washington

GREEN or freshly cut lumber contains from 40 to 80 per cent. of water. A portion of this water exists in a free state in the cavities of the wood cells, and the remainder is absorbed by the walls of the wood cells. It is possible that in green wood the water in the cell walls is in some form of chemical combination with the wood substance, for if timber is once thoroughly dried, the wood will not re-acquire all of the characteristics of green wood upon soaking in water. Sapwood contains much more water than heartwood, and this water also contains plant food material. When sapwood is dried this food material remains, and this is one of the reasons why sapwood is not as resistant to decay as summer wood as this dried sap is available as food for wood destroying fungi. Trees contain as much or more water and sap in the winter than in summer.

Seasoning consists in removing the water from the wood.[1] Wood that has been dried for an indefinite period of time at 212 degrees F., or "oven-dry" wood, still contains about seven per cent. (by weight) of water, but this water is in actual chemical combination with the wood substance. We can therefore consider that practically speaking, oven-dry wood is perfectly dry. Before wood can be used for most purposes it must be seasoned, for when wood dries it shrinks greatly in volume. This amount of shrinkage varies very much with the species of the wood. Thus pignut hickory may shrink as much as 20 per cent. in volume when dried carefully from a green to an oven dry condition, while arborvitae (northern white cedar), shrinks but 7 per cent. in volume. Hardwoods, as a rule, shrink very much more in drying than conifers or softwoods, the average shrinkage of 30 American hardwoods being about 15 per cent. in volume, and the average shrinkage of 18 American softwoods being about 10 per cent. Douglas fir shrinks about 11 per cent. in volume, bald cypress about 11½ per cent. and longleaf pine about 13 per cent. The shrinkage is greatest in a tangential direction, because the dense, heavy-walled summer wood is continuous in this direction and the wood in a given species shrinks in proportion to the amount of actual wood substance that is present. The shrinkage in a radial direction is much less, for the wood in the annual rings is alternately dense and open, and therefore the amount of wood substance in a radial direction is not so great. The radial shrinkage of 27 hardwoods dried from a green to an air dry condition, was 6 per cent., while the tangential shrinkage was 10 per cent. When dried in a similar manner the radial shrinkage of 18 conifers was 3½ per cent., while the tangential shrinkage was 6½ per cent. The longitudinal shrinkage of most woods is so very slight that it may be disregarded. The unequal shrinkage of the wood causes serious checking when the wood is carelessly seasoned. Round timbers, such as piling or poles have a strong tendency to develop radial checks in seasoning, due to the internal stresses developed by the greater shrinkage in a tangential direction. When a certain amount of moisture is present the wood has a certain degree of plasticity (*i. e.*, it will yield and can be moulded without breaking or checking). When wood is slowly and carefully dried, this plasticity allows it to shrink with but a little checking. Carefully kiln-dried lumber shrinks more than oven-dried lumber, and with less checking, for in kiln drying the wood can be made to dry evenly, thus retaining a certain amount of plasticity until almost thoroughly dry.

CAUSE OF CASEHARDENING.

When wood is rapidly and carelessly dried, the outer portion dries out to a much greater degree than the interior and becomes comparatively nonplastic. Such a condition is known as casehardening. When the interior of case-hardened wood dries out and shrinks, the outer case of nonplastic wood does not yield because of its lack of plasticity, with the result that the interior develops "hollow horning," or large checks, similar to heart or star shakes, which are invisible from the surface of the wood.

The seasoning of wood is further complicated by the fact that the water in the wood evaporates much more rapidly from the ends or cross sections of the timbers than from the longitudinal surfaces. This introduces more complicated stresses that have a very great tendency to cause excessive checking near the ends of the timbers. In order to avoid this checking, it is common practice to paint the ends of valuable timbers with oils or paraffin compounds, thus entirely preventing evaporation of moisture from the cross sections. In mill practice, with our common softwoods, such a procedure is, of course, too expensive, and therefore amount of drying of the ends can be controlled only to a limited extent by placing lumber piles close together so as to cut down the circulation of air. If the "stickers" or spacing lath that are placed between each layer of lumber in a lumber pile are placed flush with the ends of the lumber, end drying and other subsequent checks will be retarded to a certain degree. The stickers should always be as narrow as possible.

In piling lumber for air-seasoning the piles should be carefully built. Every pile should be on a good solid foundation slanting away from the runways or platforms and there should be at least a foot of air space between the bottom of the pile and the ground. The sills for the piles should be preferably treated with a preservative. If they are supported on cedar blocks, or upon concrete block footings, painting the sills or bottom row of lumber with creosote will suffice. If these precautions are taken, the lumber will not readily decay and become degraded, yet in the average yard very little attention is paid to the foundation for the lumber piles. In building the pile, the lumber should be carefully and evenly stacked, and the stickers or cross-sticks should be placed so that they are uniformly parallel from the top to the bottom of the pile to avoid warping of the lumber. Lumber that has a tendency to warp can be successfully dried with a minimum amount of warping if proper precautions are taken in piling. Poor piling will ruin a large percentage of the most easily dried lumber. The tops of the piles should be slanted by placing double stickers at the ends of the last few layers of lumber so that rain water will run off without soaking all of the timber in the pile.

The length of time required for air seasoning varies greatly with the species of the timber, the dimension of the lumber, the manner of piling and the time of the year. In Western Washington and Oregon, lumber will season only very slowly during the winter months, due to the excessive humidity at this season. During the summer months seasoning is very rapid. In this climate, lumber that is piled in late fall and is allowed to season until late summer, usually seasons with a minimum amount of checking and warping. Due to the rapid drying during the summer, summer piled lumber has a much greater tendency to check. The time required for seasoning softwoods to an air-dry condition (*i. e.*, when the wood contains only from 15 to 20 per cent. by weight of water) varies from six months to two years. Thin stock will, of course, dry much more rapidly than large dimension stock.

ADVANTAGES OF AIR-SEASONING.

The following points may be considered as the main advantages of air seasoning. The timber seasons slowly, so that checking is ordinarily not severe. For local trade where underweights are not important, this method of seasoning is cheap and a stock of lumber must necessarily be kept in the yard regardless of any consideration of seasoning.

On the other hand, the practice of air seasoning has certain disadvantages. In the first place, if the lumber is to be really air seasoned, a stock as large as the output of the mill for six or eight months must be kept on hand, with the result that a large amount of capital is tied up and yielding no revenue. The fire risk in such large lumber yards is, moreover, very great. In addition to these disadvantages it is not possible to season the lumber to a definite moisture content, and much lumber is degraded because of checking and decay, especially in the higher grades.

At the present time it seems that one of the inevitable developments in the lumber industry will be the extensive adoption of artificial seasoning or kiln drying of all grades of lumber, including common dimension stock. Freight rates for the shipment of lumber by rail are based upon the weight of the carloads of lumber, and as lumber is bulky in proportion to its weight, it is possible to dry the lumber and save the cost of shipping the water otherwise contained in the wood. Water has a specific gravity almost twice as great as dry wood, and as the cost of artificially removing the water from the wood, or kiln drying, is less than the amount that is saved in freight rates on the long hauls of lumber to the middle west from the Pacific States, such artificial drying is a paying proposition. In the shingle industry, almost all of the profits made by millmen during the past lean years have been the saving of freight charges in underweights. This led to the excessive drying or baking of red cedar shingles which injured the shingle industry to an enormous extent. The organization of the shingle manufacturers in Washington and Oregon and the production of an honest "rite grade" shingle that is properly dried, and not baked, has been a great step forward.

KILN DRYING BEST METHOD OF SEASONING LUMBER.

Almost any lumber can be dried more successfully in a dry kiln than by any other means, provided that the dry kiln is properly constructed and operated. In many otherwise up-to-date and efficient mills, as much as 10 to 20 per cent. of the timber that is kiln dried is lost by degrading due to checking. The dry kilns are usually run on a "by-guess-and-by-gosh" basis, and the loss of timber is accepted as inevitable. As a matter of fact, very little lumber should degrade if the kiln is properly constructed and handled, but the kiln man or operator should have nothing to do but to tend to the dry kilns. The kiln operator should also be technically trained, and he should have a salary in just proportion to the saving that he is able to make in reducing the 10 to 20 per cent. of degrading mentioned above.

In addition to the saving of freight charges, kiln drying has a number of other great advantages. In the first place, the lumber can be dried to a definite moisture content. Such lumber can be planed to a definite size with the assurance that the subsequent dimensions of the timber when placed in a building will be a known quantity, and can be accurately matched at any future time. While this advantage is of especial importance with the finer hardwoods, it is also worth while when dealing with softwoods. Another advantage of this method of seasoning lies in the fact that in the case of resinous woods, the resin in the ducts and pitch streaks is solidified, due to the high temperature employed in the kiln, and such kiln dried lumber can be varnished with the assurance that the finish will not be ruined by the exudation of pitch globules through the varnish. Proper kiln drying also reduces the tendency of the wood to swell and warp when moisture is reabsorbed.

Among some operators there is a tendency to overdry lumber. Nothing substantial is gained by such practice, as wood that is dried until the moisture content is much less than five to eight per cent. is made unnecessarily dry, and unless it is loaded on cars directly from the kiln trucks, it will reabsorb moisture from the air until the moisture content reaches 10 to 12 per cent. depending upon weather conditions. Bone-dry lumber is, moreover, not as readily planed as less completely dried material. Furthermore, when the wood is dried below a certain moisture content, depending upon the efficiency of the kiln, the cost of the additional drying proportionately increases very much.

SOME KILN DRYING PRINCIPLES.

Before describing the types of dry kilns that are in common use, it may be well to consider more fully the underlying principles of kiln drying. To kiln dry lumber successfully, the rate of drying of the interior and the exterior of the lumber should be as nearly as possible the same. To do this successfully the lumber must be heated in air that is incapable of absorbing moisture; that is, the relative humidity of the hot air in the kiln must approach 100 per cent., until the timber is heated through to the center.

Relative humidity is the ratio of the amount of water vapor actually in the air to the amount of water vapor that the air is capable of absorbing at that same temperature. At temperatures above 212 degrees F., to prevent drying the wood must be surrounded by an atmosphere of saturated steam. When the air that has a relative humidity of 100 per cent. is cooled, it loses a portion of the water vapor, which condenses and collects as dew. Water will not evaporate when the relative humidity of the surrounding air is 100 per cent., and as the relative humidity of the air is lowered from this point, the rate of evaporation of water increases in direct proportion. The evaporation of water is accompanied by a reduction of temperature, and this reduction of temperature is varied in proportion to the rate of evaporation. This principle is employed in determining the relative humidity of air by

*From the *West Coast Lumberman*.

[1] It is, however, impossible to remove all of the water without destroying the wood.

means of a psychrometer. This apparatus consists of two similar thermometers, one being provided with cotton wick constantly saturated with water, which is wrapped around the bulb. As the water evaporates from the wick, the bulb is cooled, lowering the apparent reading upon the scale of the thermometer. By comparing the readings of the two thermometers and referring to a table (tables showing the relative humidity and giving other valuable information are found in Forest Service Bulletin No. 104, "Principles of Drying Lumber at Atmospheric Pressure and Humidity Diagram," by H. D. Tiemann) the relative humidity of the surrounding air can be determined. Another form of apparatus for determining the relative humidity is the hair hygrometer. This is constructed in such a manner that a small spring pulls constantly but lightly upon a short hair. As the relative humidity of the air is lowered, the hair dries out and contracts, and the contraction of the hair is transmitted to a pointer on a dial, indicating the relative humidity directly. These indicators must be calibrated or corrected from time to time by means of a psychrometer.

TIME REQUIRED.

The time required to heat the timber through to the center varies with the species of timber, size of material and the moisture content of the wood. Partially air seasoned material may be more difficult to season in a dry kiln without excessive checking than absolutely green material. The temperature to which the wood should be heated while the relative humidity of the air in the dry kiln is 100 per cent. varies considerably with the character of the lumber that is to be dried. Douglas fir can be heated to 225 degrees F., with safety; western red cedar and spruce should not be heated to a temperature much higher than 200 degrees F. No checking will occur during this initial heating period if the relative humidity of the air in the dry kiln is maintained at 100 per cent., regardless of the temperature to which the wood is heated. To insure that the relative humidity is 100 per cent. steam should be jetted into the kiln during the preliminary heating period. The amount of steam required is relatively small, if the kiln is tight.

As soon as the lumber has been heated through to the center, the temperature of the kiln should be slightly reduced, and the relative humidity should be gradually lowered every hour for a number of hours. A sudden lowering of the relative humidity will cause the lumber to check and warp badly. After the wood has partially dried due to the slow decrease in the relative humidity, the rate of drying can be increased at an increasing rate as the end of the drying period is reached. During the drying period the temperature of the kiln should not be progressively lower, but may even be increased with safety after the wood has become partially dry. Bear in mind, however, the fact that increasing the temperature lowers the relative humidity of the air in the kiln. High temperatures are more efficient from the standpoint of steam consumption than low temperatures. The reason for this lies in the fact that the latent heat of evaporation of water (*i. e.*, the number of heat units required to evaporate a given quantity of water) decreases with an increase in temperature. Thus while 606.5 heat units are required to evaporate a unit quantity of water at 32 degrees F., only 571 units are required at 122 degrees F., 534 units at 212 degrees F., and 494 units at 302 degrees F.

POINTS TO BE CONSIDERED.

The points to be considered in successful kiln-drying are therefore, as follows:

(a) The timber should be heated through before the drying begins.

(b) The air should be very humid at the beginning of the drying period and be made drier only gradually until the lumber contains only about 20 per cent. of moisture.

(c) Near the end of the drying period the rate of drying can be increased without causing checking or warping.

(d) Control of the drying process at any given temperature must be secured by controlling the relative humidity.

(e) The temperature of the lumber in the kiln must be maintained uniformly throughout the entire pile.

(f) High temperatures permit more rapid drying than do lower ones. The higher the temperature of the lumber the more efficient is the kiln. Temperatures as high as the boiling point are not injurious to most woods, providing all of the other fundamentally important factors are properly considered. Some species, however, cannot stand as high temperatures as others.

In its simplest form a dry kiln consists of a large room provided with a track upon which truck loads of lumber may be pushed into the room. The room is also provided with a large door at one end that can be widely opened to admit the truckloads of lumber. Under the track are a number of one-inch black iron pipes, called a "steam coil," connected with a steam supply.

The operation of such a kiln is very simple. The lumber is trucked into the room, one truck load filling the room, and the door is tightly closed. Live steam is then circulated through the steam coil. The heat radiated from the steam coil warms the air in the room, and the air in turn conveys the heat to the lumber. This causes the lumber to season; at first rapidly, then as the relative humidity of the room rapidly increases through the addition of this evaporated moisture, the rate of drying decreases. As the air is heated it expands, and the excess of air escapes from the room through cracks in the walls and around the doors. As the heating continues and the temperature rises above 212 degrees F., moisture is evaporated from the wood by direct vaporization. As no ventilators are provided on the kiln, this vaporized water must escape through cracks in the kiln and as the cracks are not large enough to allow the vapor to escape at atmospheric pressure, a slight internal pressure in the kiln is developed. No provision is made for the circulation of air or vapor in the kiln.

THE PROGRESSIVE KILN.

Curiously, fairly good results can be obtained in drying Douglas fir by this method. (With certain species of woods this method could, however, not be used.) Such a kiln has the defect, however, that the relative humidity cannot be effectively controlled at will, and therefore the rate of drying cannot be increased when the point has been reached when an increased rate of drying would no longer cause the lumber to warp and check. As no provision for circulation of air is made in such a kiln, the lumber has a great tendency to dry unevenly, and the maximum rate of drying cannot be obtained. To hasten the drying of lumber in the kiln the so-called "Natural draft" kilns were devised. These kilns differ from the simple non-draft kiln in that an attempt is made to hasten the drying by allowing the heat from the steam coils to create a strong draft in the kiln. Most natural draft kilns are also of the "progressive" type, differing from the simple kiln described in the first paragraph of this lecture in that doors are provided at each end of the kiln. A progressive kiln is also longer than a simple charge kiln and accommodates a number of charges or truckloads of lumber. Each time a truck-load of dried lumber is removed from one end of the kiln, another truck load is charged into the kiln at the other end. A progressive kiln therefore contains a number of charges in various stages of dryness. The end from which the dried lumber is removed from the kiln is known as the "dry end." At the dry end of a natural draft kiln one or more cold air ducts are provided. These ducts, which are simply means for admitting outside air into the kiln, terminate in a pit under the steam coils at the dry end of the kiln. As the air rises through the steam coils it is heated to a high temperature, with a consequent lowering of its relative humidity. The wood nearest the dry end of the kiln is therefore subjected to the greatest drying effect. As the air passes through the kiln it accumulates more and more moisture that has been evaporated from the wood. At the green end (that is the end into which the green lumber is charged into the kiln) the hot air is lowered in temperature and has a high relative humidity, so that the green lumber that is charged into the kiln is not at once subjected to the maximum drying effect of the air. At the green end ventilators allow the hot air to escape from the kiln. When all of the lumber that is charged into a progressive dry-kiln is of the same size, moisture content and density, good results can be obtained. The operator of the progressive kiln is expected to control the drying of the lumber by opening and closing the cold air ducts. When the air is still, the amount of air passing through the kiln can be fairly well regulated, but when a moderate wind is blowing, it is difficult to do so. Moreover, when lumber of different dimensions is charged into the kiln, it is difficult to dry the lumber correctly.

IMPORTANCE OF PROPER CIRCULATION.

The natural-draught kilns were devised by persons who labored under the misconception that a large volume of air is necessary in order to dry the lumber. It is impossible to dry lumber properly when a large volume of air rushes through the kiln, as the temperature of the air and the relative humidity cannot be accurately controlled. Two of the most important factors in drying lumber are temperature and relative humidity. It is necessary therefore in drying lumber to convey a certain number of heat units to the wood through the medium of the air in the kiln, and to remove the evaporated water from the wood with this same air at a certain rate of speed. The kiln first described in this article is defective in that no provision is made for the circulation of the air in the kiln in order to accomplish this object. This lack of circulation makes the drying ineffective in several ways. The heat units are not conveyed to the wood in an economical manner, they are distributed irregularly, and as the hot air currents rising from the steam coils do not penetrate into the centers of the lumber piles on the trucks the moisture is removed from the wood in an irregular manner. With temperatures above 212 degrees F., this is not true to the same extent.

Kilns have been developed which make provision for the circulation of air in the kiln. The circulation may be produced artificially, as when air is removed from one end of the kiln and returned to the other end by means of a power driven blower or fan, or it may be naturally induced by building false walls in the kiln and placing cold water coils of sprays between the false walls and the other walls the space between the walls communicating with the pit under the heating coils of the kiln. The lowering in temperature of the air between these walls by the cold water causes it to become denser, and sink, thus stimulating circulation in the kiln.

LUMBER MUST BE PROPERLY PILED.

In general, there are two methods of stacking lumber for drying in the kiln: 1. Flat piling; 2. Edge piling. When lumber is flat piled, chimneys or openings must be left in the courses in the pile, so that the heated air can circulate through the centers of the loads. In every case, it is preferable to build "square ended" loads; that is, to build the truck-loads in such a manner that the boards of each course end on the same sticker, so that the ends of the boards do not stick out irregularly from the truck-load. Edge piled lumber is usually piled by mechanical stackers, such stacking being quickly and cheaply done. From the standpoint of efficiency in drying, due to the ease with which the heat can be circulated around the lumber, edge piling is by far the best system, depending also, of course, upon the type of construction of the kiln.

Experiments by H. D. Tiemann, at the U. S. Forest Products Laboratory, have established the following basic facts which must be borne in mind in considering the circulation in a dry kiln: 1. Hot air is lighter in weight than cold air. 2. Steam is lighter in weight than air, therefore, moist air is lighter in weight than dry air at the same temperature. 3. When hot air impinges upon a piece of cold green lumber, it absorbs moisture, but the increase in density due to cooling is greater than the decrease in density caused by the absorption of evaporated moisture. Hence, hot air that passes through a pile of green lumber will have a tendency to descend in the kiln.

INSTRUMENTS IMPORTANT.

The proper operation of a dry-kiln depends to a large extent upon the location of the thermometers, hygrometers and other indicating devices, which should preferably be of the recording type, but as the proper location of these varies considerably with the different types of kilns, it is not possible to take up in detail the matter of the location of instruments in this article. In fact, this is a problem that must be solved by the individual dry-kiln operator, who to be really successful should be a technically trained man.

In some cases high temperatures cannot be used successfully in kiln drying, although as I have indicated before, the temperature that is used is of less importance than the relative humidity. In the case of sugar pine, for example, temperatures are usually kept very low during the kiln drying to avoid "kiln burn," which is a brown stain that develops in the wood during the seasoning period. Nevertheless, sugar pine can be very successfully dried with a minimum amount of kiln burn if a comparatively high temperature and low relative humidity is used for a short period when the lumber is first placed in the kiln. This should be followed by a heating period with a fairly high temperature (about 175 degrees F.) and a relative humidity of about 90 per cent. until the lumber is heated through to the center. The relative humidity may then be decreased so that the lumber will dry rapidly. If green frozen maple is heated in air of high relative humidity, a similar stain appears. This stain can be avoided by drying the maple at a temperature of 120 to 130 degrees F., and at a low relative humidity (about 60 per cent). While this procedure is not correct from the standpoint of efficiency in drying, the loss in degrading due to brown stain, when the maple is dried in what would otherwise be the most efficient manner, is greater

and more important than the loss in checking and the loss of time under these conditions.

Much information on kiln drying can be obtained from the publications of the U. S. Forest Service, which are of great value to practical dry kiln operators. It is expected that experiments to demonstrate the practicability of a new method of drying Douglas fir will shortly be inaugurated in the experimental dry kiln of the College of Forestry, which was constructed by the North Coast Dry Kiln Company. The results of such experiments will be published in some later issue of the *West Coast Lumberman.*

"Blue Coal"

(Continued from page 157)

mouth of the Trieux) would be barred with dikes and divided into two parts constituting new systems of basins, thus creating powerful generating stations; the turbines operating alternators and forming an admirable system for transmitting power to a distance.

Besides the necessity of constructing the dams as solidly as possible and of protecting the apparatus against violent shocks of the sea, the establishment of those basins involves the construction of various systems for protecting the openings (locks, sluices, clack-valves, gates, etc.); there are many conditions to be fulfilled, solidity, water-tightness, ease and rapidity of operation, etc., which offer a wide field to the ingenuity of inventors.

How much power may we hope to capture by these basins? According to Prof. A. Berget, each square kilometer on the surface of the sea corresponds to 20,000 h.p., the bay of Mont Saint Michel alone, where at the equinoxes the flood tide exceeds 14 meters, would supply one-fourth of the power required by French industry. Decoeur estimates that in practice there could be obtained from the tides of the English Channel, by means of turbines, a minimum of 300 h.p. per square kilometer of the basin; a force attaining 600 h.p. for tides with an amplitude of 5.5 meters, the expense being computed at 1,000 fr. ($200) per h.p. of the installation (including all machines, dams, etc.).

Systems With Closed Reservoir.—In these systems the motive power is the air compressed or rarified by the play of the tide in an enclosed space.

The compression of the air involves certain complexities of construction; since the reservoirs which will resist the pressure are very costly to build, even when of small size; the cost soon becomes prohibitive when the volume is increased. Rarefied air, on the other hand, offers certain advantages. In a recent work, *Blue Coal*, Dr. Max Legrand, describes an ingenious process devised by him and based on this principle. His station comprises a solidly walled closed cistern communicating with the sea (Fig. 9); when the tide rises it fills the cistern, driving out the contained air through a valve. The opposite effect is produced by the falling tide: the water in flowing out produces above it a difference of pressure, and consequently, by means of a pipe communicating with the outside, a current of air. This current is employed to actuate a special motor, a sort of balanced wheel, having a number of teeth on its surface. When the wheel revolves the crest of these teeth gently grazes the neck of a frame into which they fit precisely. When suction is set up in this apparatus the pressure of the air acts upon the cogs and causes the wheel to revolve. This hydropneumatic motor is capable of developing 0.83 h.p. for a fall of 2 cm. per min. of the water in a cistern having a surface of 10 sq. m., supposing a rotation of one revolution per second and a cogged surface of 10 sq. cm.

Applications of Blue Coal.—By erecting such apparatus as are described above on our French coasts, which represent, including islands, some 3,500 kilometers, we might hope to capture millions of horse power at an extremely low cost. Our whole industrial economy might thus be altered, plants forsaking the vicinity of mines to seek regions where power is cheaply available; the mountains for white coal, the coasts for blue coal; and the latter region would likewise facilitate the transport of raw materials and of manufactured products.

Obviously one of the first adaptations of this marine energy will be its transmission to a distance by means of electricity; moreover the manufacturer will here be in close proximity to the inexhaustible chemical stores of the ocean, from which it may be possible to extract chlorine and its derivatives, sodium salts, etc.

As Pr. Berget observes in the organ of the Maritime League, "The ocean is the inexhaustible storehouse of energy; this natural energy demands only a little human energy to become fecund. Shall we long lack the latter?"

Biology of a Life-Table

At a recent meeting of the Royal Statistical Society a paper was read by Dr. J. Brownlee entitled "Notes on the Biology of a Life-Table." Dr. Brownlee pointed out that a life-table contained a record of the natural history of the life-processes of man from birth to death. As man must be looked upon in the light of a physico-chemical engine with the power of working for a certain time, it should be possible to obtain from the different life-tables some indication of the rate at which the engine works and the manner in which the power of working is altered by different environments. That some law exists is shown by the relationship between environment and ill-health advanced by Dr. Farr forty years ago. He established a relationship for the decade 1861-70 that $D = c^{\delta^p}$, where D is the death-rate, δ the number of persons living per sq. m., and c and p are constants. Unfortunately, Dr. Farr could only use crude death-rates, and his law was not found to apply in the subsequent decades. Now, however, it is possible to use life-table death-rates.

It is found, when the different areas in the country are arranged in groups according to their different death-rates, the groups being so large that the effects of different local conditions are averaged out, that the death-rate increases directly as the tenth root of the density of the population as measured by the number of persons on each square mile. The equations for the three decades for which statistics exist are as follows:

1861–70	...	...	$D = 12.42^{\delta^{\cdot 10015}}$
1881–90	...	...	$D = 11.45^{\delta^{\cdot 09760}}$
1891–1900	...	...	$D = 10.82^{\delta^{\cdot 10179}}$

It follows from this that there must be some definite law underlying the life-processes, and that between the different life-tables close relationships should exist. In an endeavor to find these relationships, Dr. Brownlee has made various experiments. In the first instance it was found that if a suitable upper limit to life were assumed, the expectations of life at all ages between ten years and seventy-five years, and the differences of the upper limit of life and the actual age when plotted on double logarithmic paper, lay on a straight line. This gives a relationship $E_x = a(C-x)^n$, where C is the upper limit of life, E the expectation at age x, and a and n are constants. It is further found that n, C, and log a used as co-ordinates are collinear. The limited range through which the formula could be applied, however, and the fact that the upper limit of life was in most tables quite ridiculously low suggested a search for a better expression. He found on trial that the formula which represents the reaction between a substance and a ferment, when the reaction is such that combination takes place between the substance and the ferment, followed by dissociation as the alteration of the substance proceeds, gave an adequate graduation. Taking the amount of the original substance to be represented by the expectation of life, the relationship between age and expectation is thus given in the following form:

$$e^{cx} = \frac{e^{cx} - e^{cE}}{E}.$$

When this formula is used, c and a are collinear for all life-tables, and c and n are collinear for each definite epoch, the epochs investigated being the decades 1861-70, 1881-90, 1891-1900, and the three years 1910-12. Further, it is found that all the latter lines are parallel. The constant direction of these may be assumed to be associated with the fact that the exponential relation of the death-rate to the density given by Farr's law is constant. The changing position of the line may also be associated with the change in the multiplying factor, which, as has been seen, has been continuously decreasing. A theoretical drawback to using the formula as given above is that it assumes that the expectation of life is an adequate measure of vitality. This assumption implies that each year of life is of equal value, and therefore equates a year of life lived between twenty and twenty-one with a year of life lived between seventy and seventy-one, though the rate of action of life-processes must be very much greater in the former case than in the latter. This difficulty, however, can be got over when it is noted that the same formula graduates, not only the expectation of life, but also the life insurance premiums, so that it may be taken that any simple law of decay expressible by a geometrical progression acting as life goes on may be included in the argument.

Dr. Brownlee thought that the relationships first given by Dr. Farr, and now found to apply for forty years in England and Wales, as also the relationship between the constants in the formula used for graduating the expectations in the life-tables, showed that the response of the human engine to different conditions was not arbitrary, but governed by very special laws.—*Nature.*

Use of Sulfuric Acid in the Sedimentation of Kaolins

Kaolins are purified by agitating them with a very dilute solution of sodium hydroxide, decanting the fluid with the clay in suspension, and adding just enough sulfuric acid to neutralise the alkali previously added and to facilitate the deposition of the kaolin. The treatment sometimes increases the plasticity of the kaolins, but this may be prevented by adding less acid. The formation of a black scum or discoloration is due to the use of an excess of sulphuric acid. The most suitable amount of acid must be ascertained by trial, as it differs with each clay. Usually it is desirable to employ rather less acid than is equivalent to the soda used.—*Trans. Am. Ceram. Soc.*

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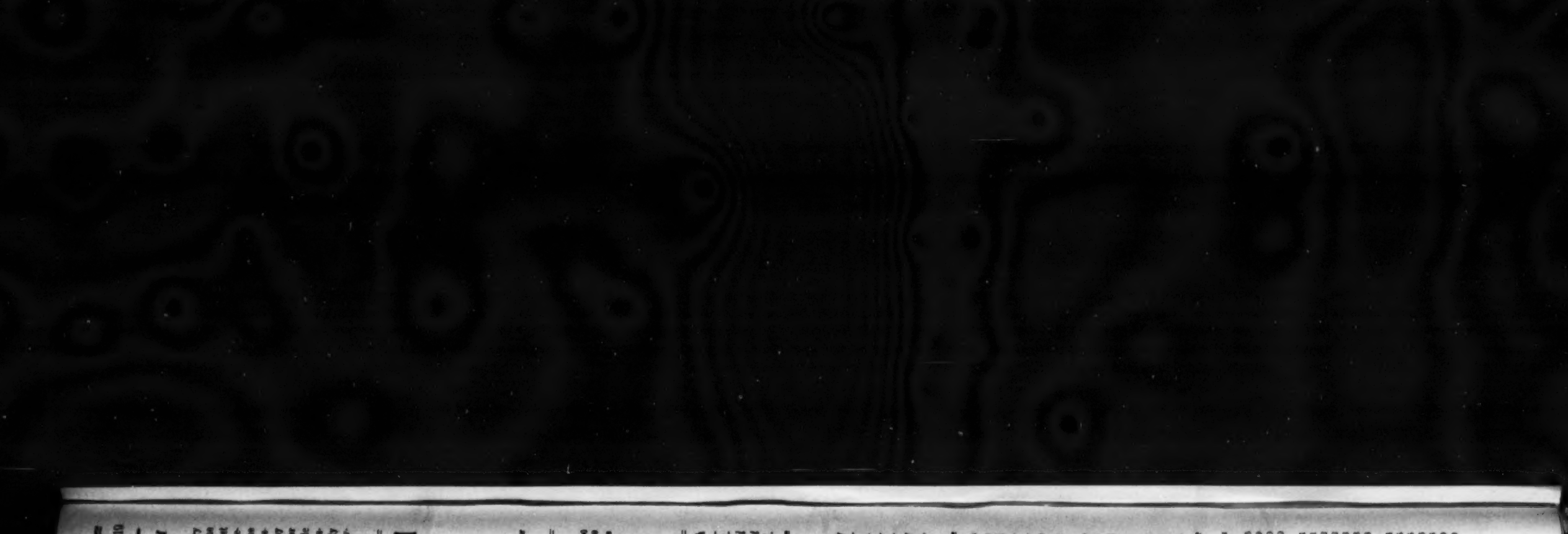
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